AD 747016

AFFDL-TR-72-47

F-102A EIGHT-CHANNEL FLIGHT LOADS DATA RECORDING PROGRAM

EUGENE DURKEE

TECHNICAL REPORT AFFDL-TR-72-47

MAY 1972

Approved for public release; distribution unlimited.

AIR FORCE FLIGHT DYNAMICS LABORATORY
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Copies of this report should not be returned unless return is required by security considerations, contractual obligations, or notice on a specific document.

AIR FORCE: 13-7-72/100

AFFDL-TR-72-47

F-102A EIGHT-CHANNEL FLIGHT LOADS DATA RECORDING PROGRAM

EUGENE DURKEE

Approved for public release; distribution unlimited.

AIR FORCE FLIGHT DYNAMICS LABORATORY
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

AFFDL-TR-72-47

FOREWORD

This report, which comprises data acquisition, processing, and analysis of F-102A maneuver loads data, was prepared by the Design Criteria Branch, Structures Division, Air Force Flight Dynamics Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio. This effort was performed under Research and Development Project 1367, "Structural Design Criteria for Military Aerospace Vehicles," Task 136717, "Structural Flight Loads Data Acquisition and Analysis on USAF Military Aircraft." Mr. Clement J. Schmid was the project engineer and Mr. Eugene Durkee was the task engineer.

The F-102A airplane S/N 57-70835 was an Air National Guard airplane under loan to Headquarters San Antonio Air Materiel Area (SAAMA), Air Force Logistics Command, Kelly Air Force Base, Texas, for a Structural Load/Stress Spectrum-in-Flight Survey. Concurrent to the SAAMA program, eight-channel flight data were collected with the Whittaker 8-channel magnetic tape recorder for design criteria development.

The maneuver loads data acquisition program began in April 1968 and terminated in April 1970. Data flights were very infrequent due to airplane maintenance problems.

Appreciation is extended to Messrs. Eugene Brazier and Clement J. Schmid for their helpful suggestions during the preparation of the data analyses and the report.

This technical report has been reviewed and is approved.

GORDON R. NEGAARD, Major, USAF
Chief, Design Criteria Branch
Structures Division

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Air Force Flight Dynamics Laboratory Wright-Patterson AFB, Ohio 45433	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

F-102A Eight-Channel Flight Loads Data Recording Program

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Report (April 1968 - April 1972)

5. AUTHOR(S) (First name, middle initial, last name)

Eugene D. Durkee

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
May 1972		3

8a. CONTRACT OR GRANT NO	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 13671709	AFFDL-TR-72-47
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Air Force Flight Dynamics Laboratory Air Force Systems Command Wright-Patterson AFB, Ohio 45433

13. ABSTRACT

This report describes the composite F-102A maneuver loads program comprising instrumentation, data acquisition, processing and analysis of the maneuver loads data as experienced by F-102A airplane S/N 57-70835 from April 1968 to April 1970. The primary objective of this program was to collect typical interceptor type maneuver loads data for the refinement of structural design criteria for interceptor type aircraft.

The maneuver loads data were processed and analyzed on the IBM 7094 computer in accordance with six computer programs which were previously prepared and designed to apply maneuver loads data to the development of structural design criteria. Results of the analyses are presented herein in the form of curves, graphs, and envelopes to provide a basis for extending the state-of-the-art in structural design criteria for current and future flight vehicles.

Data evaluation reveals a deficiency in the design limit normal load factor. The maximum load factor recorded during this program was 8.5 "g" which exceeds the design limit load factor by 1.5 "g." A survey of nine previously conducted programs on fighter-type aircraft reveals that depending on mission requirements, the design normal load factor should be in the range of 8.2 to 8.9 "g." The maximum recorded acceleration (8.5 "g") is within this recommended range of design accelerations. The roll, pitch, and yaw rate values indicate that asymmetrical maneuvers were not severe. The design airspeed of 655 knots or Mach 1.5, whichever occurs first, was exceeded by 44 knots. However, because of the limited number of data hours accumulated during these tests, no judgment can be made relative to damage and aircraft life.

DD FORM 1 NOV 65 1473

UNCLASSIFIED

Security Classification

1119

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Maneuver Loads Flight Loads Data Digital Recording Multi-Channel Recording Automated Data Processing Design Criteria						

☆U.S.Government Printing Office: 1972 — 759-087/671

UNCLASSIFIED
Security Classification

iv

TABLE OF CONTENTS

LIST OF FIGURES

List of Figures (Continued)

List of Figures (Continued)

List of Figures (Continued)

LIST OF SYMBOLS

Symbol	Definition
g	Acceleration due to gravity, 32.2 feet per second per second
HP	Pressure altitude, feet
H_z	Frequency, cycles per second
KIAS	Knots indicated air speed
K	Knots
M	Mach number
N_x	Longitudinal load factor at aircraft center of gravity
N_y	Lateral load factor at aircraft center of gravity
N_z	Normal load factor at aircraft center of gravity
N_{ze}	Effective normal load factor = $\frac{N_z W_i}{W_D}$
PSIA	Pressure, pounds per square inch absolute
PSID	Pressure, pounds per square inch differential
P	Roll velocity, radians per second
PDOT	Roll acceleration, radians per second per second
Q	Pitch velocity, radians per second
QDOT	Pitch acceleration, radian per second per second
R	Yaw velocity, radians per second
RDOT	Yaw acceleration, radian per second per second
VAC	Volts alternating current
VDC	Volts direct current
V_e	Air speed equivalent, knots
W	Airplane gross weight, pounds
W_D	Design gross weight, pounds

List of Symbols (Continued)

Symbol	Definition
W_i	Indicated gross weight, pounds
TD	Dwell time, seconds
ϕ	Phase of alternating current

SECTION I

INTRODUCTION

This report was prepared in the interest of updating structural design criteria for interceptor type aircraft. This is part of a continuous effort to develop more definitive structural design criteria and maintain a state-of-the-art consistent with rapid technological developments in associated scientific areas as aerodynamics, propulsion, materials, mechanics, etc., and with military requirements for increased speeds, altitudes, and maneuverability.

The development and refinement of structural design criteria have been the responsibility of the Design Criteria Branch and its predecessor organizations since their inception, and as necessary to the development of practical operational aircraft for the various mission requirements as specified by the USAF including its various operational commands. Each aircraft type, having a different mission assignment, requires a different set of criteria to achieve the maximum proficiency for which it is intended.

The approach to the development of realistic structural design criteria has been accomplished through the acquisition of flight data which normally comprises velocity, altitude, and normal linear acceleration at the airplane center of gravity. Recently, these three flight parameters have been expanded to include linear accelerations in the other two airplane axes, i.e., in the lateral and longitudinal axes, and rotational velocities in all three airplane axes. On occasions, strain gages have been installed on structural members in the wing, tail, fuselage, and landing gear to collect bending moments, shear, and torsion. Also,

control forces have been collected on specific aircraft. Subsequent to data acquisition, the data are processed and analyzed with the results being presented in reports in formats appropriate to the development and refinement of structural design criteria.

This particular report presents 17.9 hours of flight loads data with their analyses from an F-102A test aircraft at Kelly AFB, Texas. This program, "F-102A Structural Load/Stress Spectrum-in-Flight Survey," was initiated by Headquarters San Antonio Air Materiel Area (SAAMA), Kelly AFB, in an effort to retrieve actual in-flight loads/stresses for comparison with original stress analysis and flight loads data and for direct application to a fatigue analysis to re-evaluate the F-102A useful operational life. Coincident with the SAAMA effort, an AFFDL instrumentation package was prepared and installed to collect 8-channel flight loads data (airspeed, altitude, 3-axes linear accelerations and rotational velocities). These data were processed through the six AFFDL computer programs which process and analyze the data for application to structural design criteria.

The test aircraft, F-102A S/N 57-70835, was an Air National Guard airplane and was loaned to Headquarters San Antonio Air Materiel Area for this program.

SECTION II

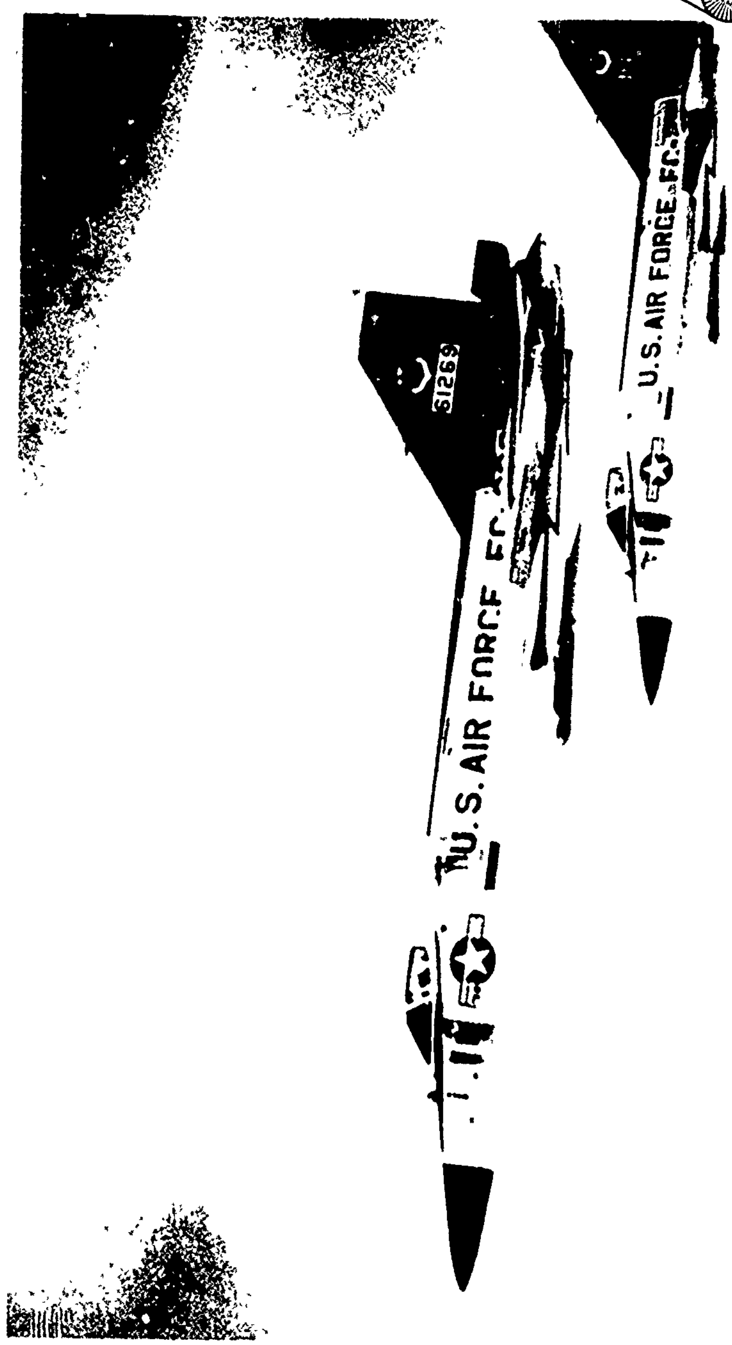
DISCUSSION

1. AIRCRAFT TYPE

An F-102A airplane, S/N 57-70835, was selected, instrumented, and test flown in an effort to retrieve actual in-flight loads/stresses for comparison/correlation with the original structural analysis, design criteria, and for a fatigue investigation and the development or refinement of structural design criteria. The F-102A (see Figure 1) is a single-place, supersonic, all-weather interceptor built by General Dynamics/Convair. F-102 airplanes are best characterized by the large 60-degree delta wing and the absence of a conventional empennage. The delta wing is equipped with elevons which provide combination aileron and elevator action from conventional cockpit controls. Conventional tricycle landing gear is utilized for take off, taxi, and landing. The wing contains six internal fuel tanks which are serviced by a single-point pressure refueling system, and fuel usage is sequenced automatically to maintain desirable center of gravity. Gross weights vary according to various mission loading conditions. Airplane gross weights range from approximately 28,150 pounds to 31,276 pounds with full fuel.

	Clean	External Tanks
Empty Weight	19,903	20,234
Usable Fuel	7,053	9,848
Armament	1,194	1,194
Total Weight	28,150	31,276

Thrust is supplied by a Pratt and Whitney J57-P-23A engine with afterburner. Approximate standard sea level static thrust rating is as



F-102A Airplane
Figure 1

follows:

Maximum (with afterburning) - 16,000 pounds

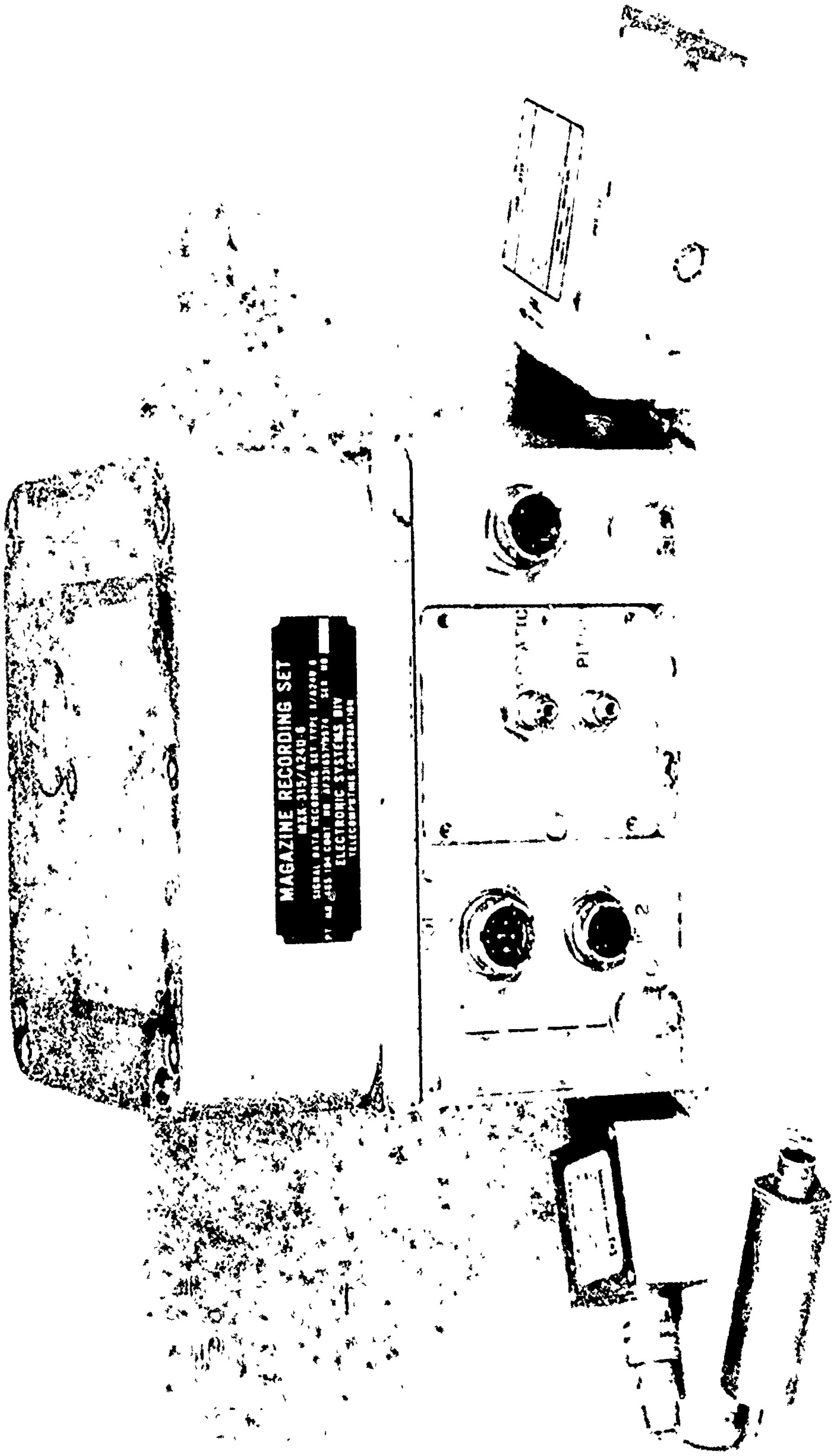
Military (without afterburning) - 10,200 pounds

The maximum allowable indicated airspeed for a clean airplane is 655 knots or Mach 1.5, whichever occurs first. For airplanes with external tanks, the maximum allowable airspeed is 435 KIAS or Mach .95, whichever occurs first. This includes either tanks empty or with fuel. The maximum positive and negative load factors for symmetrical maneuvers and for a clean airplane are: + 7.0 and - 3.0 "g." The airplane is further restricted by external tanks and asymmetrical maneuvers.

2. INSTRUMENTATION

The Whittaker 8-channel magnetic tape flight recorder and appropriate sensors were installed in the F-102A airplane by Air Force Flight Dynamics Laboratory personnel early in the program. Sensors comprised an airspeed-altitude pressure transducer, three linear accelerometers, and three rate gyros. The instruments were all laboratory calibrated prior to installation.

a. The Whittaker flight loads data recorder MXU-316/A24U-6, as shown in Figure 2, contains the analog-to-digital converter and record electronics for converting eight channels of analog data to eight channels of straight binary digital data. Each channel output consists of six binary bits and a timing track. The drive motors for the tape magazine, which are within the recorder, possess two operating speeds. In the low-speed mode, the input analog data is sampled thirty times per second and the tape speed is 3.6 inches per minute. In this mode of operation, up to 6 H_z analog data can be resolved. In the high-speed mode of operation, the analog data is sampled 60 times per second and the tape is driven 7.2



Whittaker Flight Recorder

Figure 2

inches per minute. In this mode of operation, up to 12 H_z data can be utilized.

The eight channels of flight information are fed into the multiplexer and are time division multiplexed onto a single channel. The word-pulse generator generates a separate gating pulse for each information channel. The multiplexed output is fed into the analog-to-digital converter through the automatic calibration unit. The analog information is converted into a six-bit binary word and presented to the record heads in parallel form. A timer assembly provides the system clock frequency, together with a 0.1 H_z signal for recording elapsed time, and the automatic calibration commands. The automatic calibration commands allow 10 seconds half-scale and full-scale calibration of the recorder system at the beginning of each flight.

b. The magazine assembly (MXK-315/A24U-6) contains the tape transport mechanisms, the magnetic record/reproduce heads, erase head, and the recording media. The tape is pulled at a constant speed by the rotating capstan assembly. The mechanical interface with the recorder or playback is made through jaw clutches that extend from the bottom of the magazine. Two magnetic record/reproduce head assemblies are used for both recording and reproduction, with each assembly containing 30 in-line magnetic heads. Each track is 0.010 inch wide and is spaced 0.042 inch centerline to centerline. Since the magazine is crash and fire resistant, the tape is metallic, 1-mil thick by 1.375 inches wide by 450 feet long. The magazine assembly mounts on the recorder mechanism assembly for record operation and is contained in a reinforced plastic housing designed to protect the tape and the recording thereon from aircraft crash conditions consisting of impact, explosion, and subsequent fire. The magazine assembly is restrained on the recorder by six 1¼-inch diameter, high strength bolts.

The recorder assembly requires 115 VAC, 400 H_z, 3Ø and 28 VDC power from the airplane. Recorder assembly dimensions are: 8 x 7¼ x 8-3/8 inches with a weight of 25 pounds. Total system error is less than ±2 percent. Additional recorder assembly information can be found in reference 1.

c. The dual pressure transducer within the recorder is a Pace Model CP-84. It has dual unit assemblies of variable inductance transducers operated by pressure bellows actuators. The input range of the impact channel (pitot) is 0 to 10 PSID. The static channel input range is 14.7 to 0.408 PSIA. The output range for both channels is 0 to + 5 VDC. Twenty-eight VDC are required for operation. Electrical connections are made through a nine-pin connector. The transducers are designed for a maximum error of ±1 percent over the entire operating range.

d. The accelerometer assembly, consisting of three Palomar linear accelerometers, part number 465-1002-2, S/Ns 1, 201, and 205, and buffer amplifier filters, were installed at the airplane center-of-gravity to record three axes of linear accelerations. The accelerometer in the vertical axis possessed a range of - 3.0 to + 9.0 "g." The other two accelerometers for the lateral and longitudinal each had a range of ±1.0 "g." The frequency response of the accelerometers was flat to 6 H_z. The units were designed for an overall accuracy of ±1 percent over the entire operating range.

e. The gyro assembly comprised three gyros with part number RG02-0501-1 H11. The gyros were manufactured by Humphrey Inc. The specification accuracy lists a ±1.0 percent of full scale at zero rate input increasing to ±2.5 percent of full scale at maximum rate inclusive of linearity, repeatability, and hysteresis. Gyro ranges are ±360, ±60, ±60 degrees-per second for roll, pitch, and yaw, respectively.

f. The recorder and sensors were all calibrated by Flight Dynamics Laboratory personnel within the Experimental Branch facility. The mercury manometer system was used to calibrate the dual pressure transducers. The accelerometers and gyros were calibrated on the AFFDL centrifuge table. All laboratory calibrations were measured with accurate digital voltmeters. The calibrations were essentially linear and the slopes of the calibration curves were fitted with least-square straight lines.

g. Under contract with Headquarters San Antonio Air Materiel Area (SAAMA), Southwest Research Institute installed over 200 strain gages, a fuel flow meter and pressure transducers. The three-axes linear accelerations and rotational velocities recorded on the Whittaker recorder were also recorded on the SAAMA Leach recorder. Strain gages were installed on the wing, vertical tail, fuselage and landing gear at over 200 locations as shown in reference 2.

3. FLIGHT TEST PROGRAM

F-102 airplane, S/N 57-70835, was instrumented to collect structural flight loads data for a fatigue life history program and the development of structural design criteria. Flights covered all the possibilities relative to maneuvers and gusts for an interceptor type aircraft. Programmed maneuvers for these tests included both symmetrical and asymmetrical with velocities ranging from .55 to 1.2 Mach, altitudes ranging from 1200 to 35,000 feet and accelerations from 0 to 6.0 "g." The airplane was flown at the above conditions in three configurations: clean, with pylons only (no tanks), and with pylons, tanks and fuel. For additional information regarding the various flight conditions, see reference 2.

4. DATA ANALYSIS

a. The strain gage data was processed by Southwest Research Institute and presented in reference 2.

b. The Whittaker 8-channel flight loads data were processed and analyzed on the 7094 IBM computer at Wright-Patterson AFB. These data were analyzed in accordance with methods as presented in reference 3. Under a contract with North American Rockwell Corporation, six computer programs were developed to process, analyze and present the refined data and their analyses in tables, graphs, and probability curves which are useful for application to the development of structural design criteria. The computer programs were generated for use on IBM 7094 computer.

Computer Program Number 1, "Data Reduction and Computation," reads the basic data tapes, calibrates, converts the data to standard units, computes such parameters as velocity in knots and Mach number, instantaneous gross weight, temperature, three axes linear accelerations and rotational velocitie and equivalent normal acceleration and prepares a binary output tape containing time histories of all parameters for use by computer programs 2A, 2B, and 2W. Data are input to the program at the beginning of each flight as required to compute weight changes during the flight as from dropping of stores or refueling. Any calibration changes that occur at any time during the flight are also entered at the beginning of each flight. The program then adjusts to the new weight rate or norm at the designated time in the flight. The data recorded for each flight will allow the 8-channel flight loads data to be analyzed in a number of different ways. For example, three aircraft configurations are categorized as per load factor limitations (5.0, 6.0 and 7.0 "g"). Data for these three groups

may be analyzed separately or together. Other possible populations could be grouped by mission, base, date, or aircraft tail number. Program Number 1 will read up to three input tapes and prepare one output tape. A single output tape will contain all the reduced flight loads data from three input tapes of raw data.

Computer Program Number 2A, "Peaks and Correlated Variables," detects structurally significant peaks in the time histories of the recorded and computed parameter data from Program 1 output tapes. As each peak is detected, simultaneous values of selected non-peaking parameters are recorded and stored for later evaluation by Program 3. Up to three Program Number 1 tapes can be read by Program 2A. Eight additional parameters are computed in Program 2A: wing tip helix angle, roll angular displacement, coupling parameters (PQ, PR, QR) and the three rotational accelerations ($\dot{P}$, $\dot{Q}$, $\dot{R}$). The output Program 2A tape is for use in Program 3.

Computer Program 2B, "Time Distributions and Envelopes," reads flight loading parameter data from Program 1, computes time distributions and peak envelopes of the multiparameter data, and produces tables and graphs of the results. With a full spectrum of input data, Program 2B prints 85 pages of tables containing time distributions and peak envelope data. The graphical data prepared by Program 2B are written on a tape which is then placed on a SC-4020 cathode ray tube plotter which plots 35 pages of graphs. The plotted data from the 85 pages of tables are all shown in the 35 pages of graphs. Results of Program 2B are shown in Appendix "A."

Computer Program Number 3, "Peak Distributions," utilizes the output tapes from Program 2A which contain all significant parameter peaks and correlated variables. Up to four input tapes can be used in a single run. Data can be combined with previous data by means of an updating tape, which

stores all previously processed data. Program 3 counts the frequency of peaks in given intervals, computes probabilities, prints the distributions in tabular form and produces a data tape for Program 4 to use in preparing graphs of the data. The printed output of Program 3 consists of tables of all the peak data of the recorded and computed parameters. These tables provide a comprehensive collection of data on the loading statistics of the aircraft under investigation.

Computer Program Number 4, "Peak Distribution Graphs," possesses one sole function, that is, to produce graphs of the peak distributions as computed by Program 3. The graphs are produced by means of the SC-4020 cathode ray tube plotter. Program 4 can read up to four input tapes from Program 3 and prepares one output tape for the SC-4020 plotter.

Computer Program 2W, "Automatic Warning System," is the means for the practical application of the automatic warning system. The function of this program is to read the flight loads data from the Program 1 output, compute and record peaks of selected loading parameters that exceed preassigned thresholds with the times of occurrence of the peaks. Then, if the frequency of occurrence of the peaks indicates that the actual loading environment is exceeding expectations or that an occurrence of ultimate load may be expected, a warning message is printed. Record plotting can be accomplished for normal linear acceleration and roll acceleration for visual determination of a valid exceedance.

Additional data analysis information is available in reference 3.

5. DATA PRESENTATION

The F-102A maneuver loads data and subsequent analyses are presented in figure format in Appendix "A."

a. Computer Program 2B, "Time Distributions and Envelopes" Results

Figures 3 through 11 were computed and plotted in accordance with instructions as provided in Computer Program 2B (reference 3). The total flight and maneuver time for each of these figures was 13.5 and 8.79 hours, respectively. The maneuver time (8.79 hours) is part of the total flight time of 13.5 hours. As will be noted later, this differs with the hours shown on graphical outputs from Program 4 which will be discussed later in the report. The percents of time in each column represent a percent of the total flight and maneuver times for each segment of airspeed or altitude. An inspection of the column heights shows, in some instances, a greater percent of elapsed time for maneuvers than for flight. In other words, column heights are greater, in some instances, for the maneuvers than for total flight time. This is legitimate since these are percentages. It is conceivable that 100 percent of the maneuver time could be within any one given altitude or airspeed segment along the abscissa, even though the total flight time was fairly well distributed in all the segments.

Figure 3, "Airspeed Distribution of Total Flight Time and Maneuver Time," indicates that approximately 90 percent of the flight and maneuver time occurred under 400 knots airspeed. Better control can be exercised over the degree of acceleration at lower airspeeds. The maximum recorded airspeed was 699 knots for these series of tests. The design limit airspeed for the F-102A is 655 knots or Mach 1.5, whichever occurs first. There was no indication that this exceedance of the design limit airspeed resulted in any damage to the aircraft.

Figure 4, "Altitude Distribution of Total Flight Time and Maneuver Time," shows that flight time varies from 12 to 25 percent with the maneuver time

varying from 11 to about 30 percent for each of the ranges of altitude intervals. The first two intervals do cover less altitude change than succeeding altitude intervals. There appears to be no precise way of predicting the percent of time spent in each interval. This is expected to vary depending on the base altitude and as flight mission requirements vary.

Figure 5, "Percent Maneuver Time Spent Above Value of (N_X)," shows that less than 5 percent of the time was spent outside of the range ± 0.4 N_X. This indicates that there was neither a sudden application of forward thrust nor abrupt braking. Above 20 percent on the time scale, the curve is nearly symmetrical. This would indicate, for the most part, that the degree of thrust and braking is about equivalent. The asterisks along the abscissa out to ± 1.2 N_X are not necessarily indicative of data to that limit. The table from which this curve was generated showed maximum values of + 1.0 and - 0.36. This positive value (1.0) does appear to be a little high for the available engine thrust.

Figure 6, "Percent Maneuver Time Spent Above Value of N_y," portrays a lopsided envelope for lateral load factor with most of the time spent performing maneuvers (left turns) which contributed to obtaining negative lateral load factors. Obviously, during any other series of flights with other pilots and mission requirements, this curve might be reversed to the other side of the spectrum (positive); but logically and with more pilots and flight and maneuver hours, the spectrum would be symmetrical about the zero line with an equal percent of time for both the positive and negative values (right and left turns). The degree of deviation from the zero line and on each side thereof should be approximately as shown in Figure 6 on the negative side, i.e., ± 1.0 "g."

Figure 7, "Percent Maneuver Time Spent Above Value of (N_z)," shows values up to 6.0 "g", but the percent of time at values above 3.0 "g" is minimal. Although not shown in Figure 7 because the graph was cut off at 6.0 "g", the design limit load factor of 7.0 "g" was exceeded during these tests. The highest recorded value was 8.5 "g". During one flight in June of 1968, the airplane momentarily and inadvertently went into a series of pitching oscillations, resulting in maximum load factors of -3.26 and +8.5 "g" with failures to right wing spars 3 and 5. The left wing had permanent set. Both wings were replaced and instrumented prior to further flight testing. The high acceleration (8.5 "g") occurred irrespective of maximum programmed maneuvers of 6.0 "g." If this maximum acceleration (8.5 "g") could occur once in 17.9 flight hours, then statistically this acceleration (8.5 "g") could occur 223 times in an airplane's lifetime of 4000 hours. This is in close agreement to the findings of reference 4 which surveyed nine flight data programs with conclusions that fighter-type aircraft should be designed for limit load factors within a range of 8.2 to 8.9 "g", depending on their assigned missions. Referring again to Figure 7, this envelope is not symmetrical nor is it expected to be even if more flight data were available. Normally, more time is spent performing pull-up type maneuvers than pushdowns. It is known that pilots, in general, are reluctant to perform negative "g" maneuvers.

Figures 8, 9, and 10 show percentage of maneuver time spent above values of P, Q, and R, respectively. These curves are all nearly symmetrical and of approximately the same shape. It is expected that with a larger quantity of data, the curves would be even more symmetrical about the zero line. The values are relatively low for an interceptor type of airplane. These values are in radians per second. There appears to be no design problem concerning roll, pitch, or yaw rates.

Figure 11, "Probability of Exceeding a Dwell Time (TD) When (N_z) and (M) are in Specified Intervals," shows a maximum dwell time of six seconds. The dwell times for the various acceleration values range from one second to a maximum of six seconds. The shorter dwell times cover the higher accelerations above four "g." This figure is for a Mach number range of zero to 0.6 wherein 85 percent of the maneuver flight time occurred. This is typical of the data in all other Mach number ranges. In no instance did the dwell time exceed six seconds.

b. <u>Program 4, "Peak Distribution Graphs," Results</u>

Figures 12 through 58 were computed and plotted in accordance with instructions as provided in Computer Program Number 4 (reference 3). The total flight hours used in the development of these graphs were 17.9. This is larger than the hours shown on Figures 3 through 11 which resulted from Program 2B. The same input data tapes were used for both programs. The reason for the flight hour difference is not known; apparently a data tape was rejected by Program 2B.

Figures 12 through 20 show probabilities of being in an altitude interval "HP" when the basic parameters (N_y, N_z, N_{ze}, P, Q, R, $\dot{P}$, $\dot{Q}$, $\dot{R}$) exhibit a peak. These figures are all relatively similar with the maximum probabilities occurring in the lowest altitude interval of zero to two thousand feet and generally decreasing for the higher altitudes. These figures are somewhat related to Figure 4 which relates percent of flight and maneuver time to each altitude interval; but in Figures 12 through 20, the graphs are based on the number of peak occurrences within each altitude interval. There were numerous peak occurrences in the zero to two thousand altitude interval though the time span of each maneuver was small. These figures indicate that the larger percentage of maneuvering is performed at the lower altitudes.

Figures 21 through 57, "Probability of Variable's Peak Exceeding a Value of the Variable (N_z) Given the Intervals of W, V_e and HP," are all similar in shape originating at either minus one or zero "g" and extending to six "g" with the probabilities of occurrences diminishing moderately as they approach six "g" for all the intervals of weight, velocity and altitude.

The final figure, Number 58, which is entitled, "Probability of Variable's Peak Exceeding a Value of the Variable (N_y) (Absolute Value of Peaks) Given Intervals of W, V_e and HP," is typical of all the thirty-seven figures involving the variable N_y. This figure indicates that N_y varies between zero and 0.9 "g" for probabilities to 0.085. Lateral load factor values were not excessive and are not expected to contribute to any structural failures.

Upon inspection of the programmed maneuvers and the resulting load factors, it appears significant that for most of the maneuvers the resultant load factors were higher than programmed. There were three instances where the overshoot was excessive and in a critical area. In these three cases, a 6 "g" symmetrical pull-up was specified and accelerations of 6.96, 7.05, and 8.5 "g" were recorded. Southwest Research Institute personnel were of the opinion that rather than the high "g" forces causing right wing spars 3 and 5 to fail, these failures were caused by flight retraction and extension cycling of the main landing gear or landing gear side loads, inducing loads in the side brace attach beam and, in turn, into spars 3 and 5. These gear cycling loads were probably not made a part of the original fatigue-loads program. This is supported by the fact that one F-102A training base experienced 17 cracks on the side beam attach lug for the retract cylinder. Possibly the skewed-gear induces more of these loads than does the original gear. The accident report suggested

that the spar failures occurred because of pre-existent stress corrosion cracks, dynamic loading conditions, and out-of-phase surface control deflections, rather than abnormally high accelerations. The Leach Recorder, installed by Southwest Research Institute (SWRI), showed maxima of -2.96 and +17.3 "g"; however, SWRI personnel believed there was an instantaneous electrical interruption at this time and the maximum positive acceleration should have been only 6.95 "g." (The AFFDL recorder showed maximum accelerations of -3.26 and +8.5 "g.") Both wings were replaced.

SECTION III

CONCLUSIONS

To relate the recorded F-102A maneuver loads data, most of which is shown in Figures 3 through 58, to structural design criteria for interceptor type aircraft, it is concluded that:

1. The design limit load factor of 7.0 "g" was exceeded during these tests irrespective of the fact that programmed maneuvers were not to exceed 6.0 "g." The maximum accelerations recorded on the AFFDL recorder were - 3.26 and + 8.5 "g." Subsequent to this flight wherein these design load exceedances occurred, the airplane was inspected for structural deficiencies. Spars 3 and 5 in the right wing were cracked and there was permanent set in the left wing. The accident report did not attribute the failures to the high "g" forces, but suggested that the spar failures occurred because of pre-existent stress corrosion cracks, dynamic loading conditions and out of phase surface control deflections. Both wings were replaced prior to continued testing. Statistically, if 8.5 "g" could occur in 17.9 hours, this value would be reached or exceeded 223 times in the airplane's design life of 4000 hours. In reference 4 where nine fighter-type aircraft flight loads data programs were evaluated, it was recommended that these aircraft types should be designed for load factors within the range of 8.2 to 8.9 "g", depending on their mission requirements such as air-to-air gunnery, ground gunnery, reconnaissance, etc. Results of the F-102A flight program are in close agreement with these conclusions.

2. The design limit airspeed of 655 knots or Mach 1.5, whichever occurs first, was exceeded by a significant amount (699 knots). There was

no indication that this exceedance of the design limit airspeed resulted in any damage to the aircraft. It should be noted that for these tests approximately 90 percent of the flight and maneuver time occurred under 400 knots airspeed.

3. Normal linear acceleration excursions covered time spans of from one to six seconds.

4. All other parameters (longitudinal and lateral accelerations, and roll, pitch, and yaw rates) as measured during this program were within design limits.

REFERENCES

1. Sackett, Rod and Hobel, Dan, "Nine-Channel Data Acquisition System," AFFDL-TR-65-151, Air Force Flight Dynamics Laboratory, Research and Technology Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, September 1965.

2. Ursell, C. R., Kirksey, R. E., and Overby, G. J., "F-102A Structural Load/Stress Spectrum-in-Flight Load Survey," Headquarters San Antonio Air Materiel Area (AFLC), Kelly Air Force Base, Ohio, February 1971.

3. Trent, D. J., Cowen, A. E., and Bouton, Innes, "Application of Multiparameter Flight Loads Data to Structural Design Criteria," Volumes I through IV, AFFDL-TR-68-131, Air Force Flight Dynamics Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, March 1969.

4. Durkee, Eugene D., "Application of Maneuver Loads Data from Fighter-Type Aircraft to Structural Design Criteria," AFFDL-TM-71-2-FBE, Air Force Flight Dynamics Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, August 1971.

APPENDIX A

FLIGHT LOADS DATA PRESENTATION

Appendix A consists of envelopes, distributions and probability curves of the measured and statistically analyzed flight loads data resulting from the six computer programs of Reference 3. Figures 3 through 58 depict these results and are presented on the following pages.

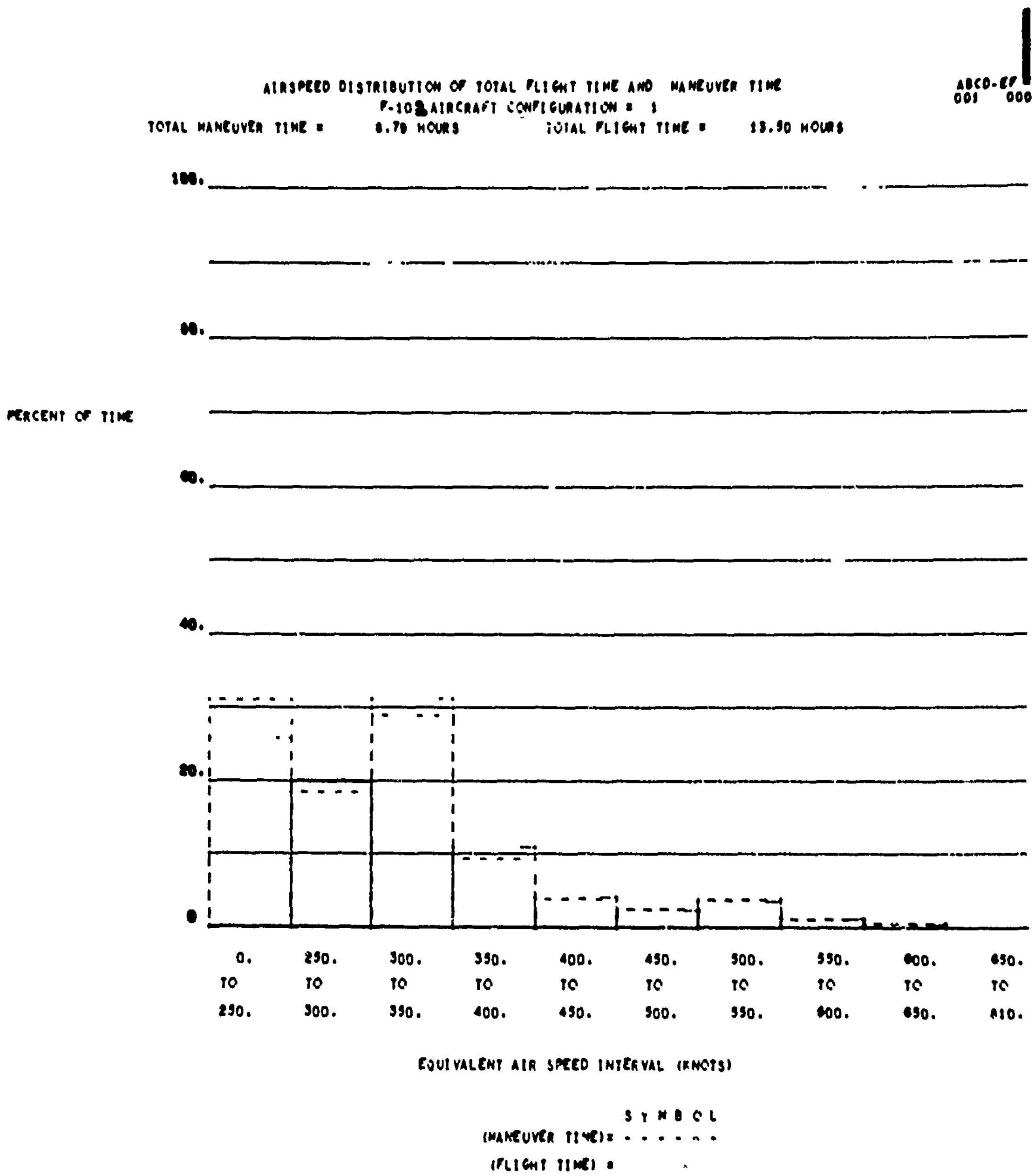

AIRSPEED DISTRIBUTION OF TOTAL FLIGHT TIME AND MANEUVER TIME
F-105 AIRCRAFT CONFIGURATION = 1
TOTAL MANEUVER TIME = 8.70 HOURS
TOTAL FLIGHT TIME = 13.50 HOURS
ABCD-EF
001 000
100.
80.
60.
40.
20.
0
PERCENT OF TIME
0. TO 250.
250. TO 300.
300. TO 350.
350. TO 400.
400. TO 450.
450. TO 500.
500. TO 550.
550. TO 600.
600. TO 650.
650. TO 810.
EQUIVALENT AIR SPEED INTERVAL (KNOTS)
SYMBOL
(MANEUVER TIME)= - - - - - -
(FLIGHT TIME) =

Figure 3

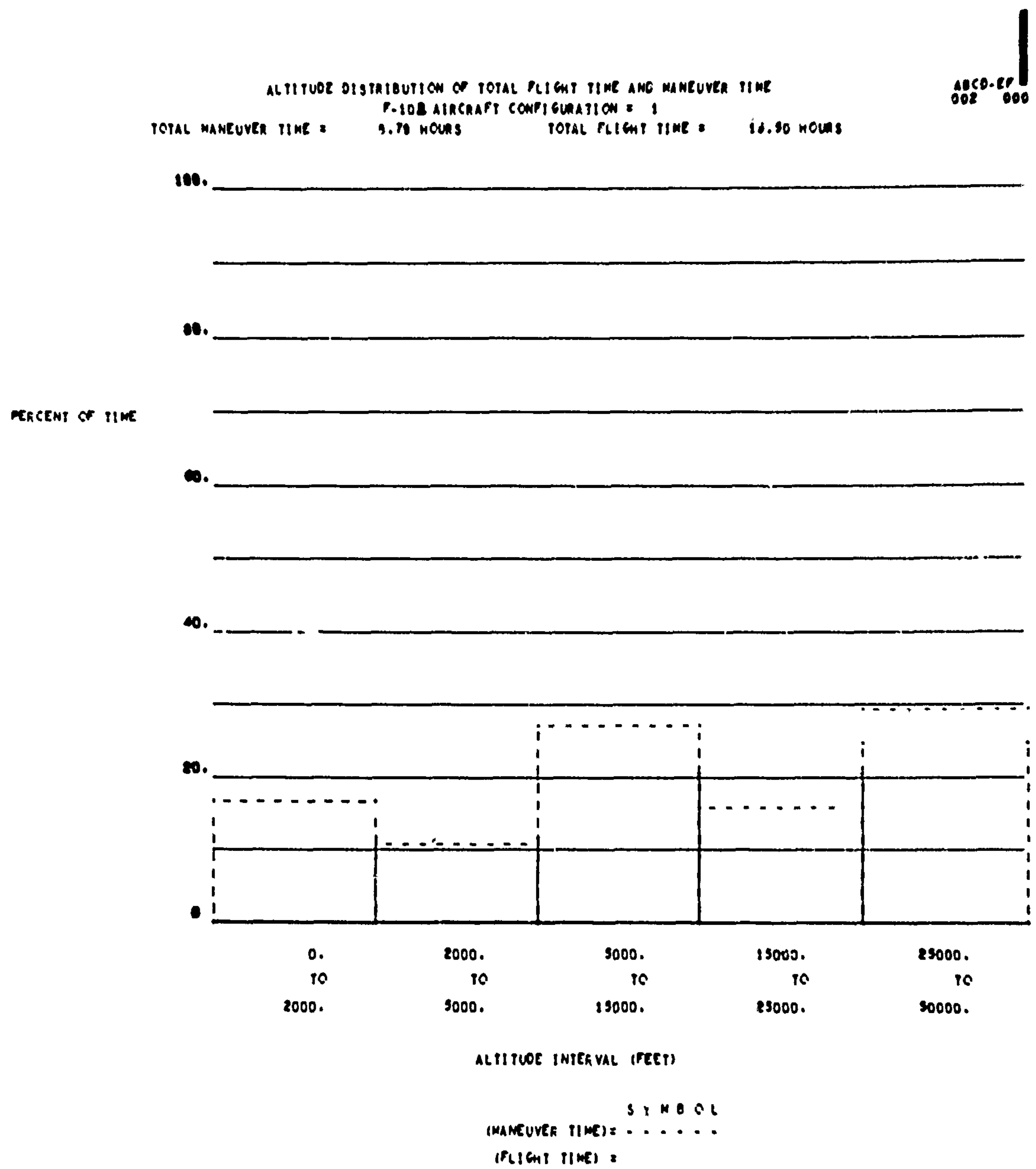

ALTITUDE DISTRIBUTION OF TOTAL FLIGHT TIME AND MANEUVER TIME
AIRCRAFT CONFIGURATION = 1
ABCD-EF
002 000
TOTAL MANEUVER TIME =
TOTAL FLIGHT TIME =
PERCENT OF TIME
100.
80.
60.
40.
20.
0
0. TO 2000.
2000. TO 5000.
5000. TO 15000.
15000. TO 25000.
25000. TO 50000.
ALTITUDE INTERVAL (FEET)
SYMBOL
(MANEUVER TIME) = - - - - - -
(FLIGHT TIME) =

Figure 4

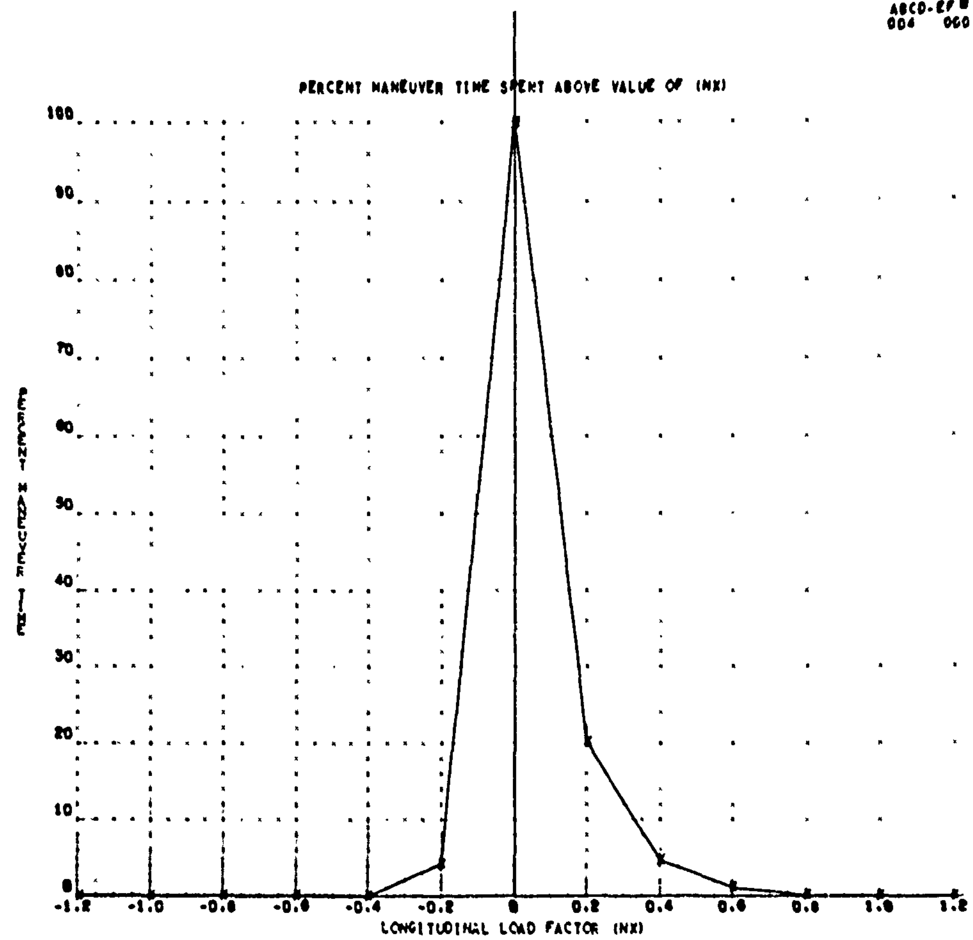

PERCENT MANEUVER TIME SPENT ABOVE VALUE OF (NX)
PERCENT MANEUVER TIME
LONGITUDINAL LOAD FACTOR (NX)
100
90
80
70
60
50
40
30
20
10
0
-1.2
-1.0
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1.0
1.2

Figure 5

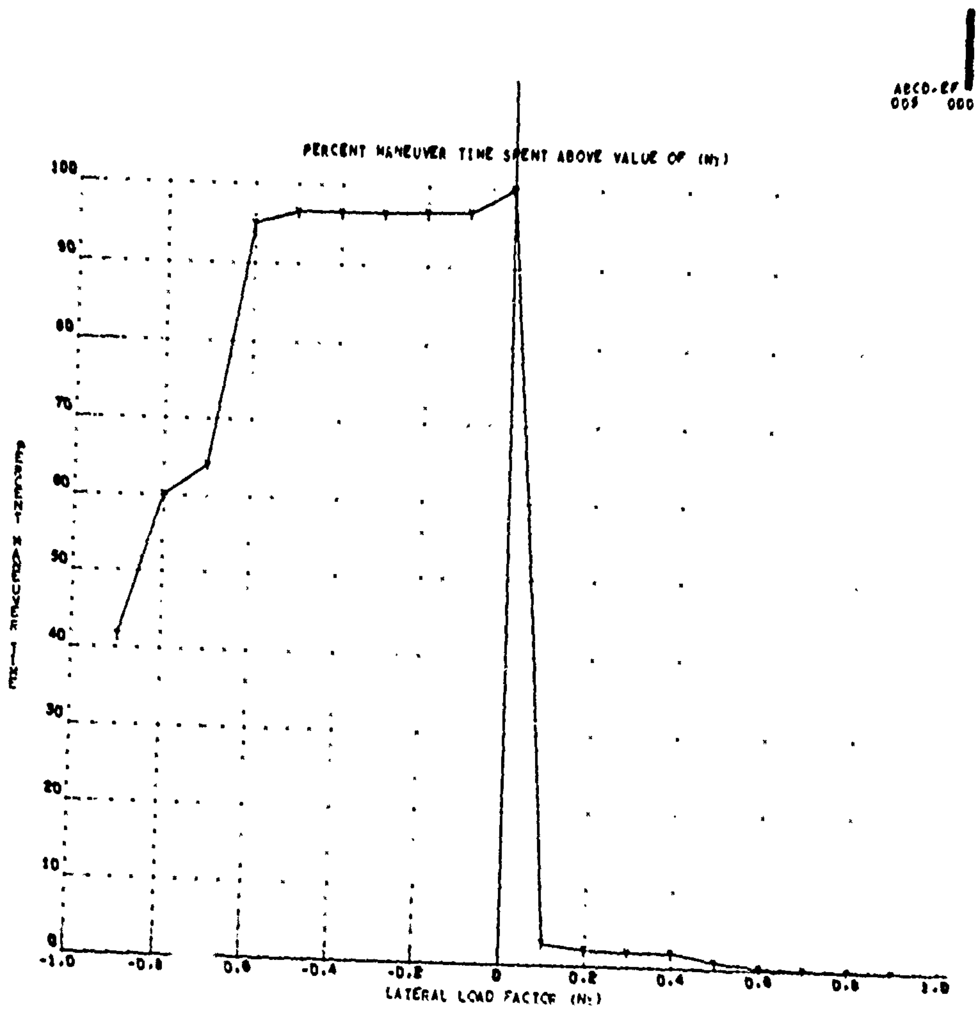

PERCENT MANEUVER TIME SPENT ABOVE VALUE OF (Ny)
PERCENT MANEUVER TIME
LATERAL LOAD FACTOR (Ny)
100
90
80
70
60
50
40
30
20
10
0
-1.0
-0.8
-0.4
-0.2
0
0.2
0.4
1.0

Figure 6

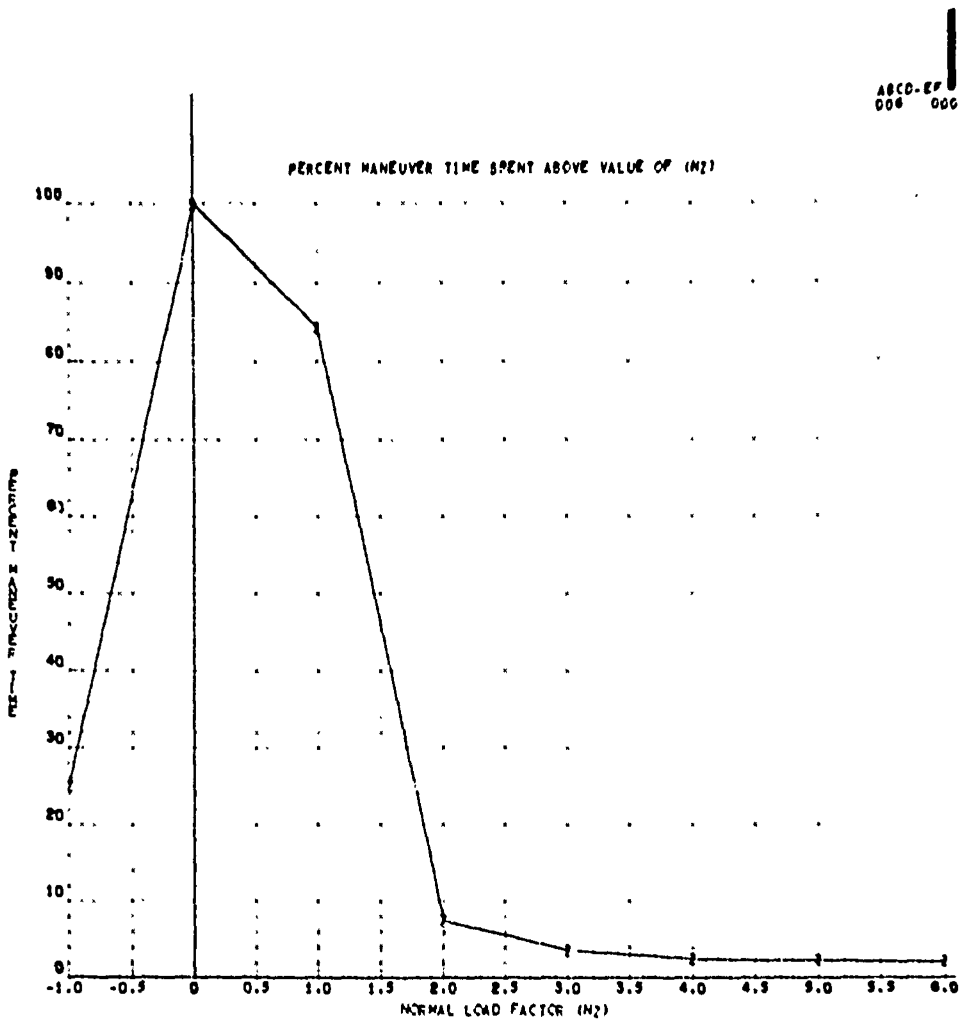

PERCENT MANEUVER TIME SPENT ABOVE VALUE OF (NZ)
PERCENT MANEUVER TIME
NORMAL LOAD FACTOR (NZ)
100
90
80
70
60
50
40
30
20
10
0
-1.0
-0.5
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0

Figure 7

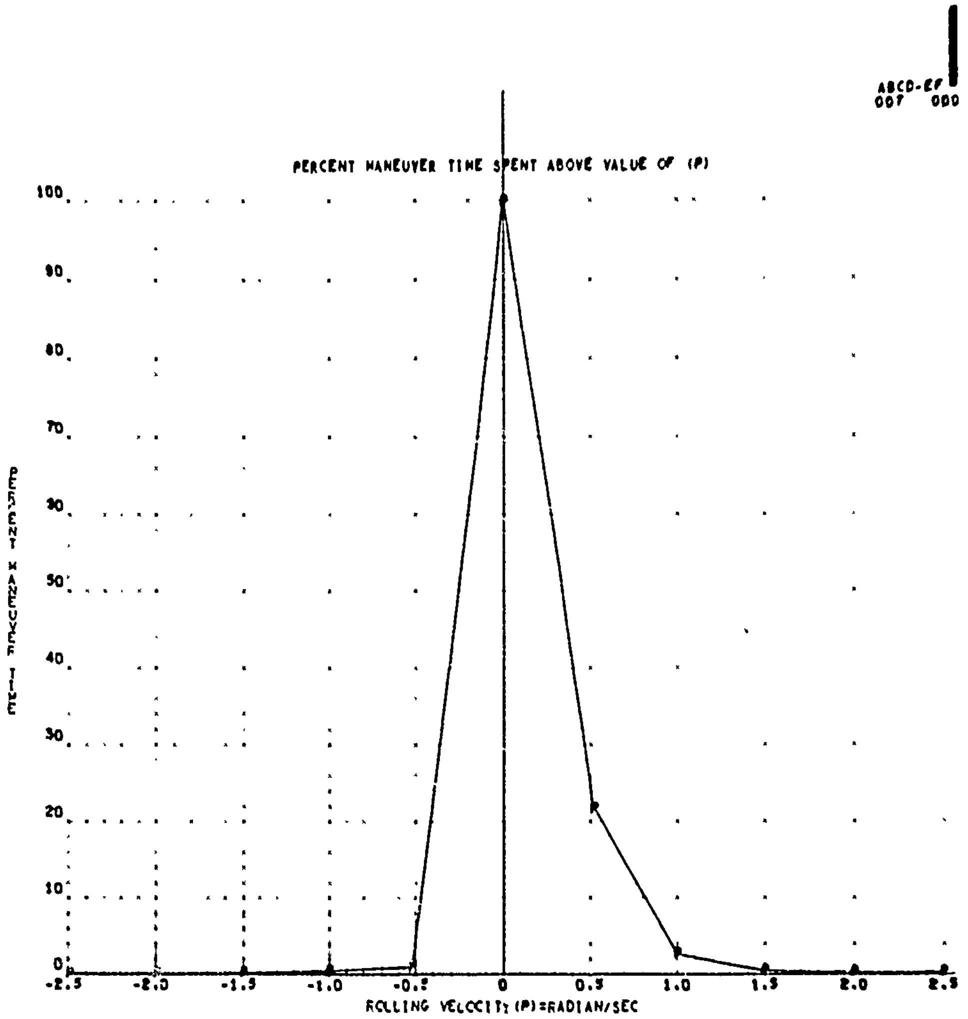

ABCD-EF
007 000
PERCENT MANEUVER TIME SPENT ABOVE VALUE OF (P)
PERCENT MANEUVER TIME
ROLLING VELOCITY (P)=RADIAN/SEC

Figure 8

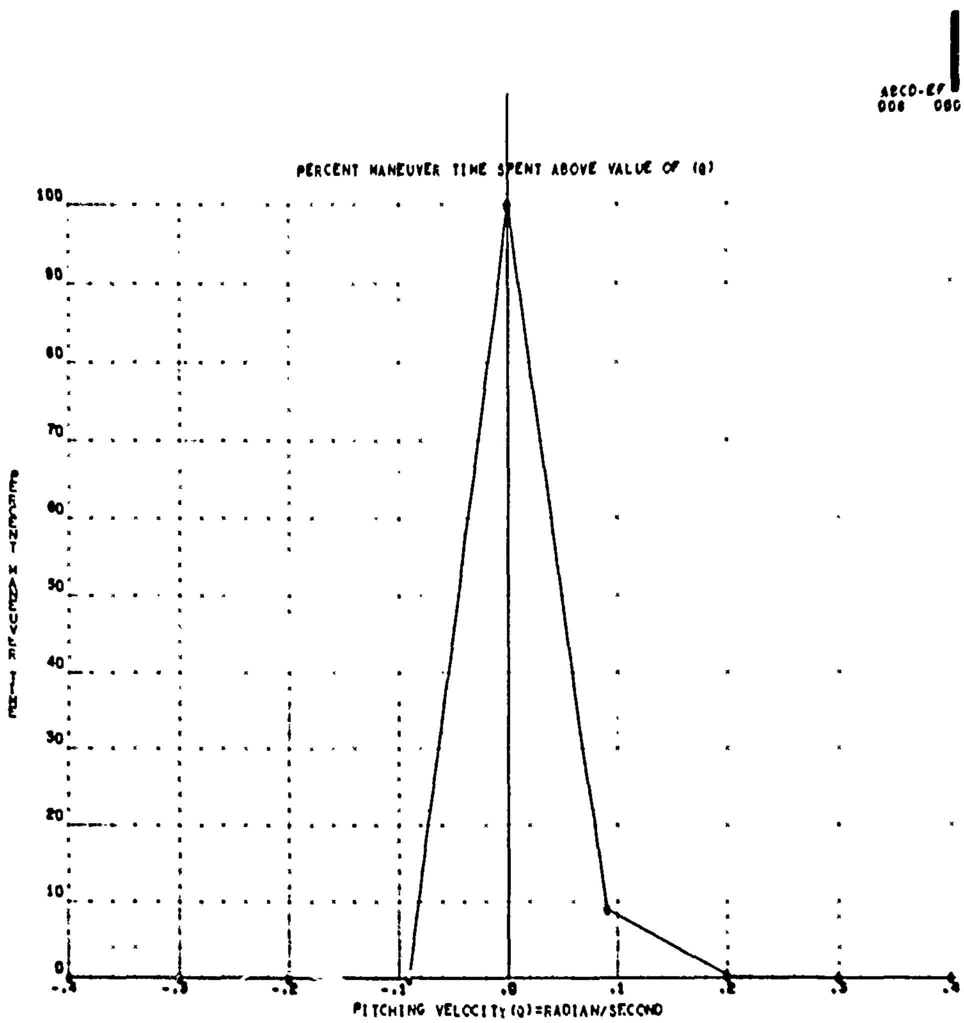

PERCENT MANEUVER TIME SPENT ABOVE VALUE OF (Q)
PERCENT MANEUVER TIME
PITCHING VELOCITY (Q)=RADIAN/SECOND
100
90
80
70
60
50
40
30
20
10
0
-.4
-.3
-.2
-.1
.0
.1
.2
.3
.4

Figure 9

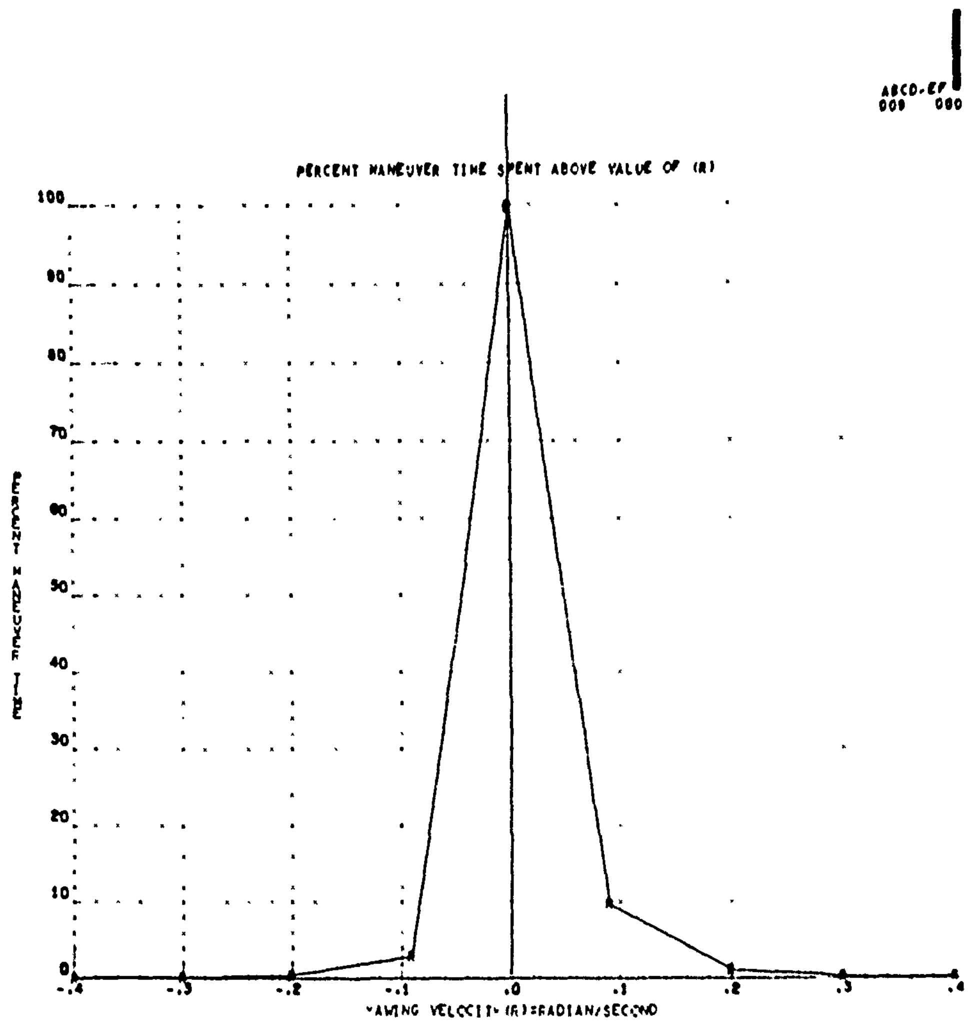
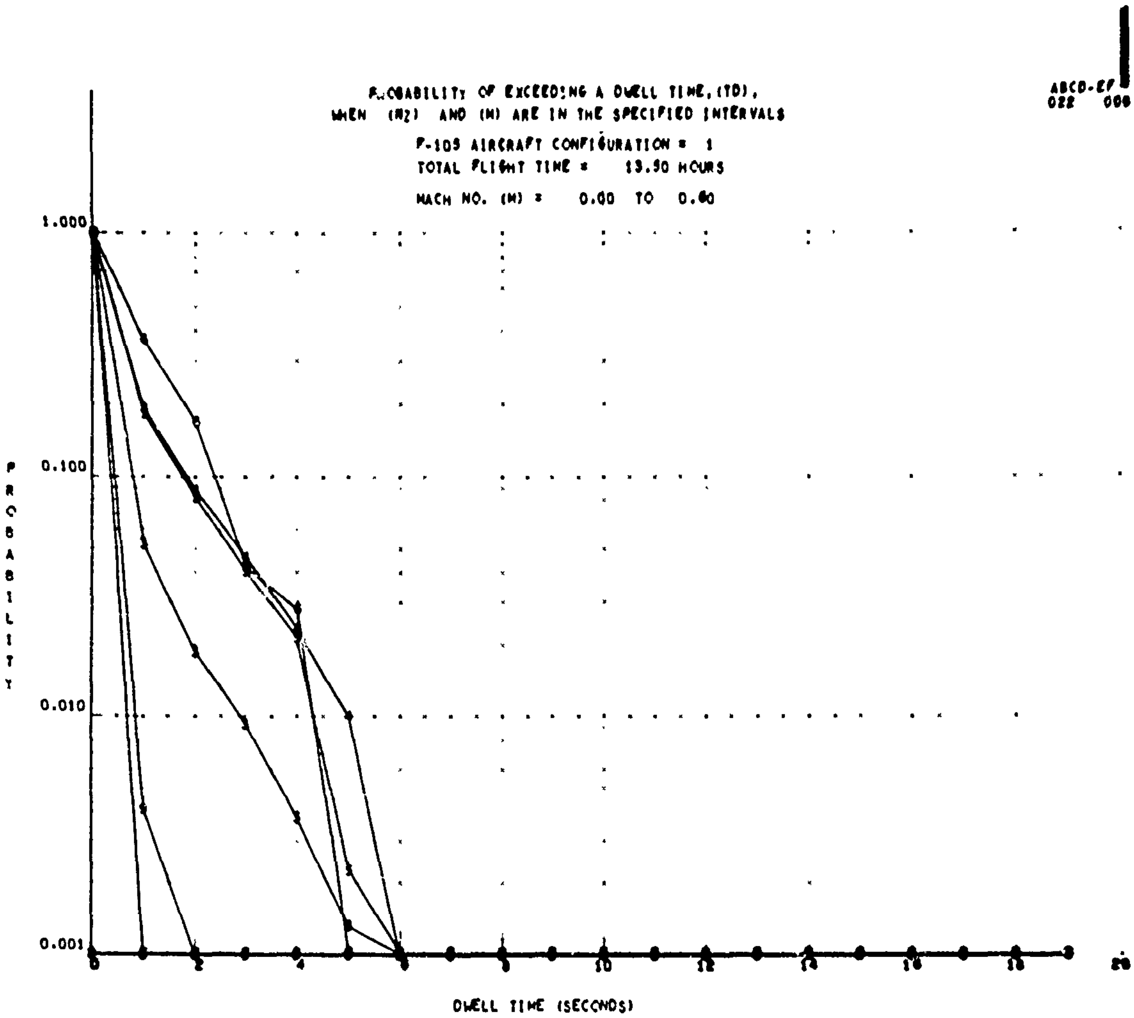

ABCD-EF
009 000
PERCENT MANEUVER TIME SPENT ABOVE VALUE OF (R)
100
90
80
70
60
50
40
30
20
10
0
PERCENT MANEUVER TIME
-.4
-.3
-.2
-.1
.0
.1
.2
.3
.4
YAWING VELOCITY (R)=RADIAN/SECOND

Figure 10

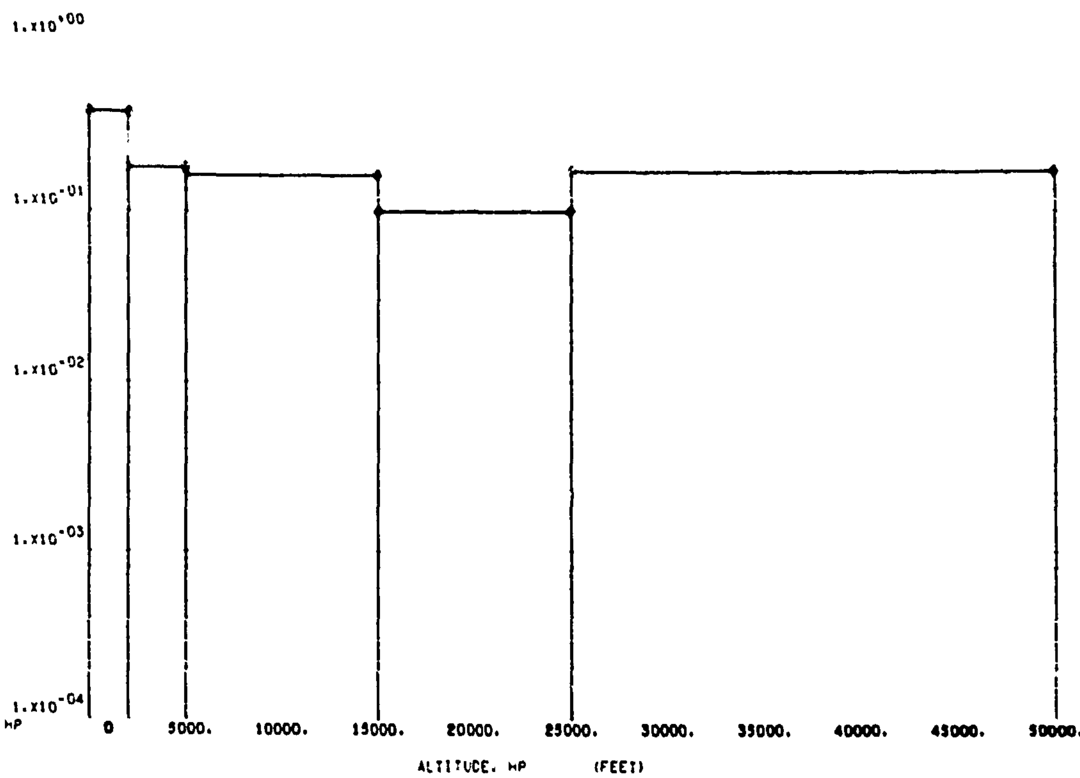


SYMBOL	LOAD FACTOR RANGE OF (NZ)
1	-2.00 TO -1.00
2	-1.00 TO 0.00
3	0.00 TO 1.00
4	1.00 TO 2.00
5	2.00 TO 3.00
6	3.00 TO 4.00
7	4.00 TO 5.00
8	5.00 TO 6.00
9	6.00 TO 7.00

Figure 11

ASCC-EF
037 000

PROBABILITY OF BEING IN AN ALTITUDE INTERVAL, HP, WHEN NZ EXHIBITS A PEAK
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.90



TOTAL NO. OF PEAKS = 17149.

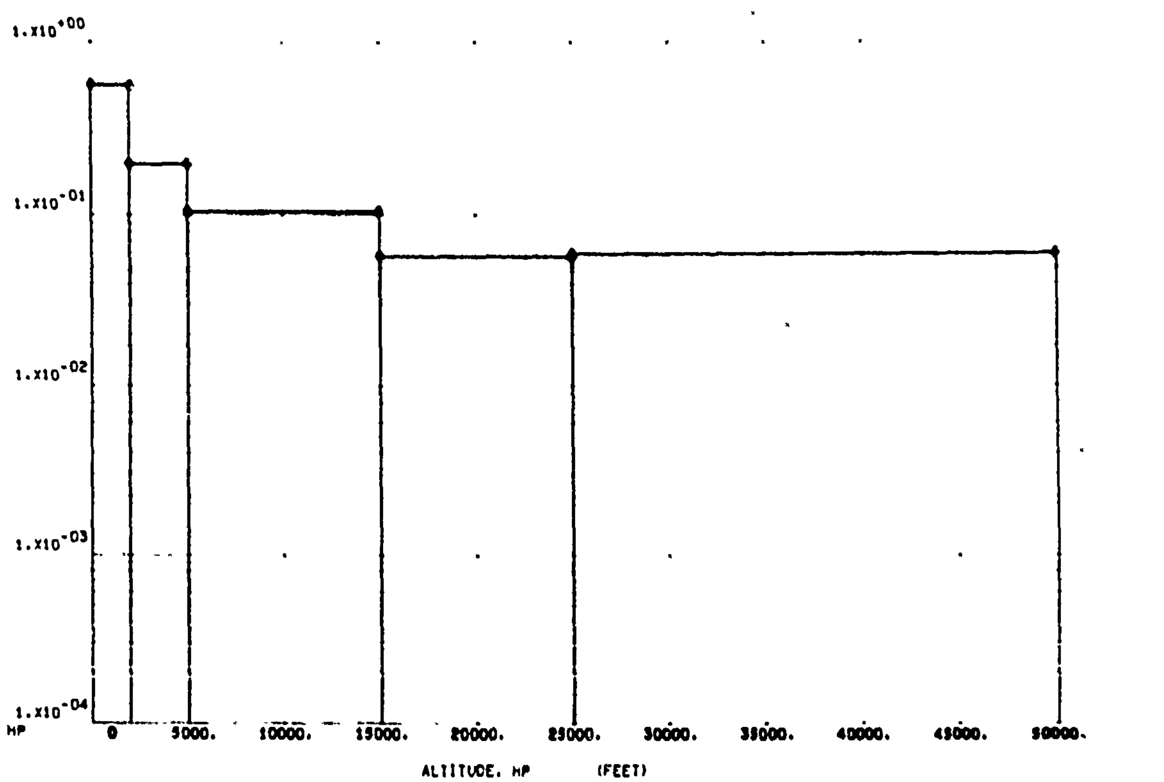
PEAKING VARIABLE (NZ)

CASE NO. 61

Figure 12

ABCD-EF
030 000

PROBABILITY OF BEING IN AN ALTITUDE INTERVAL, HP, WHEN NZ EXHIBITS A PEAK
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.90



TOTAL NO. OF PEAKS = 10886.

PEAKING VARIABLE (NZ)

CASE NO. 62

Figure 13

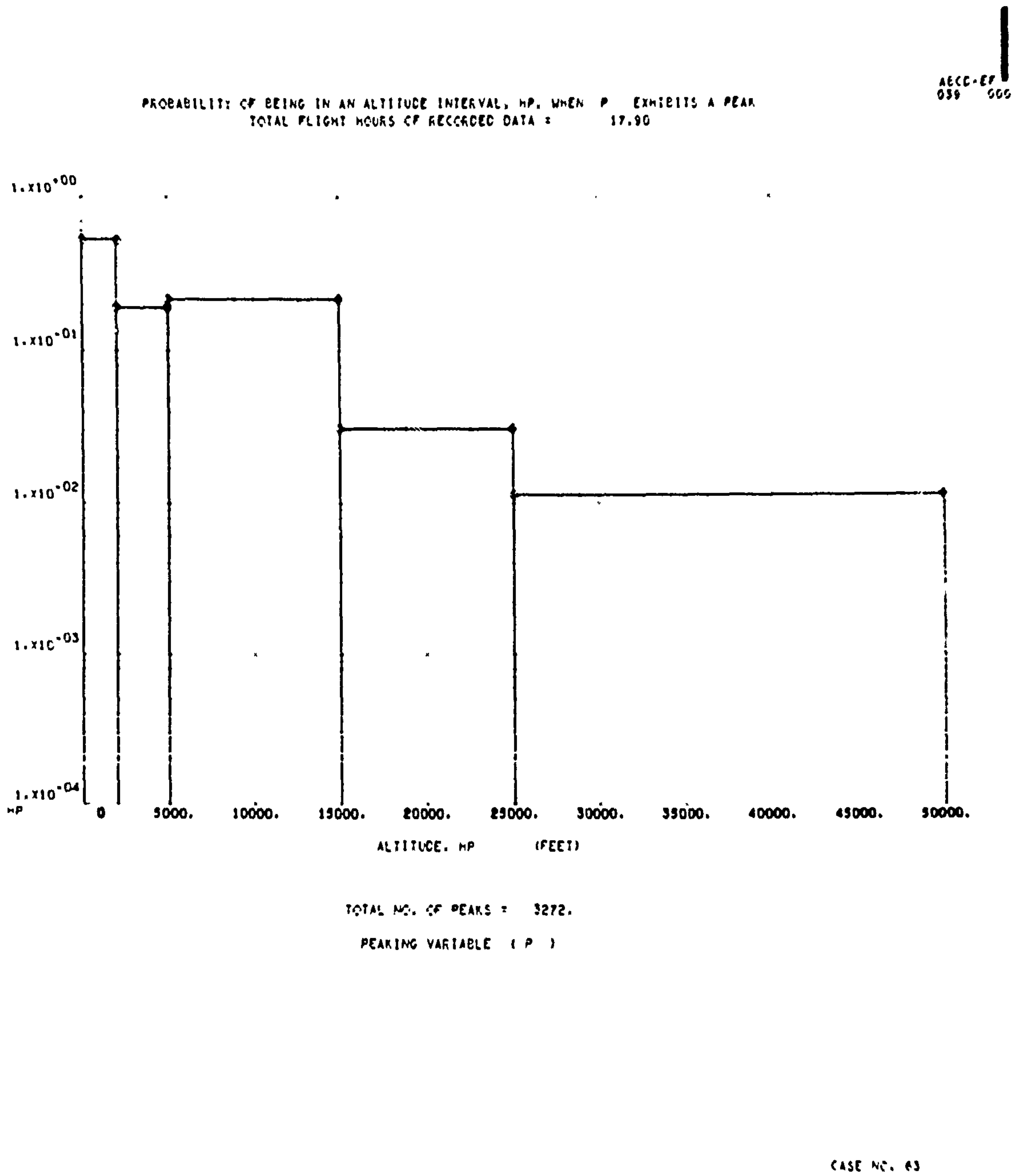

AECC-EF
039 000
PROBABILITY OF BEING IN AN ALTITUDE INTERVAL, HP, WHEN P EXHIBITS A PEAK
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.90
1.x10+00
1.x10-01
1.x10-02
1.x10-03
1.x10-04
HP
0
5000.
10000.
15000.
20000.
25000.
30000.
35000.
40000.
45000.
50000.
ALTITUDE, HP (FEET)
TOTAL NO. OF PEAKS = 3272.
PEAKING VARIABLE (P)
CASE NO. 63

Figure 14

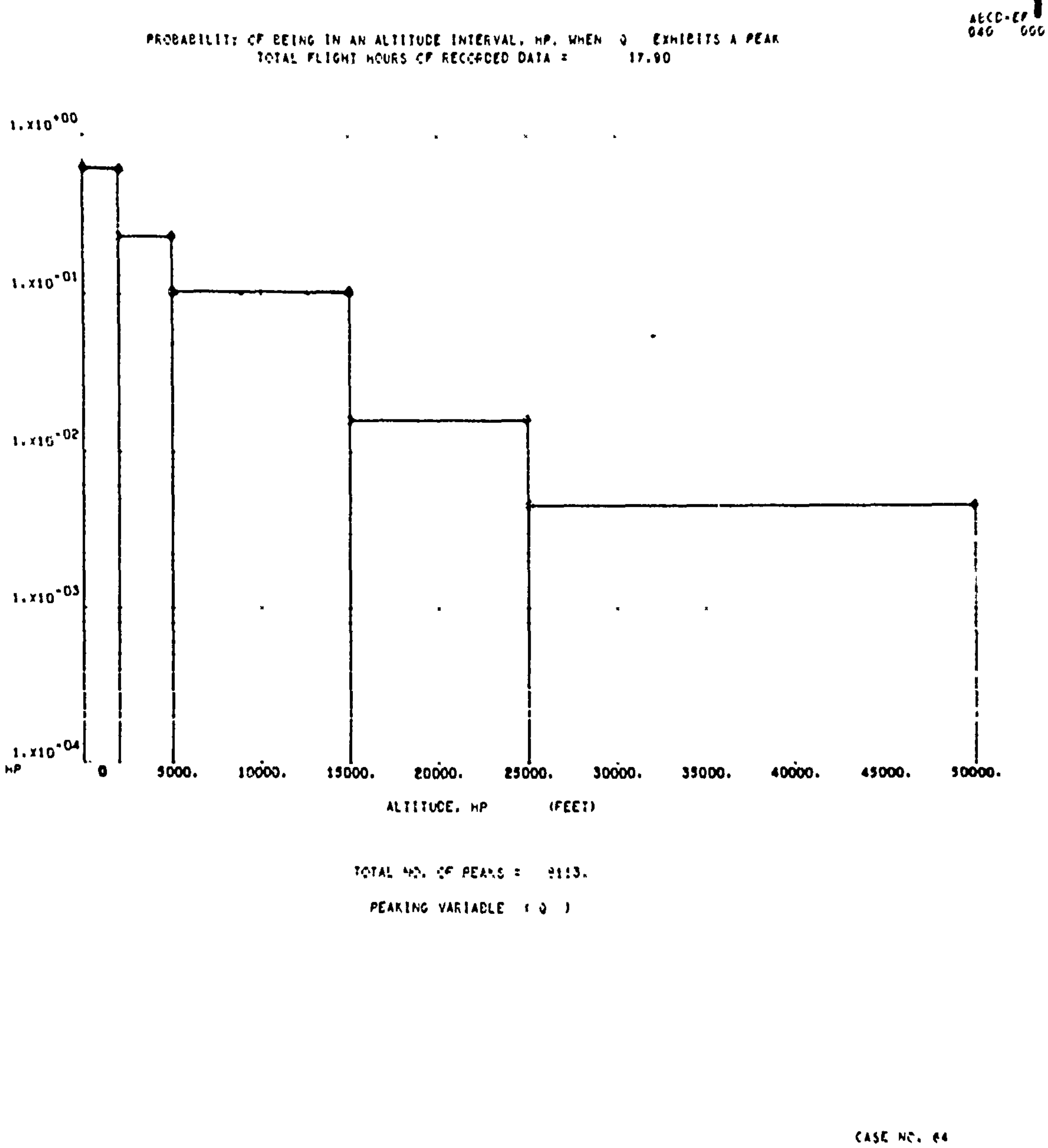

AECD-EF
040 000
PROBABILITY OF BEING IN AN ALTITUDE INTERVAL, HP, WHEN Q EXHIBITS A PEAK
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.90
1.x10+00
1.x10-01
1.x10-02
1.x10-03
1.x10-04
HP
0
5000.
10000.
15000.
20000.
25000.
30000.
35000.
40000.
45000.
50000.
ALTITUDE, HP (FEET)
TOTAL NO. OF PEAKS =
PEAKING VARIABLE (Q)
CASE NO. 64

Figure 15

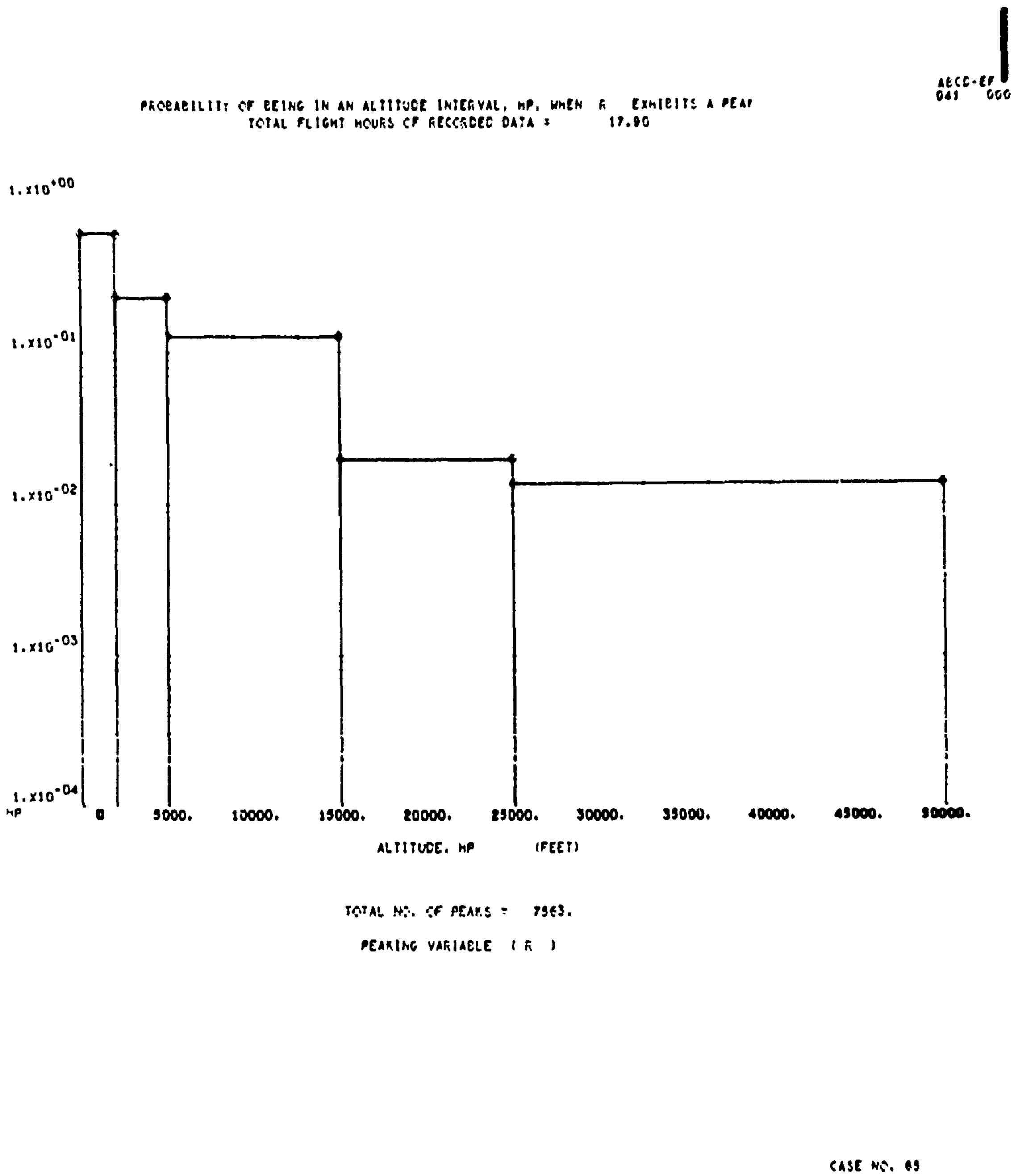

AECC-EF
041 000
PROBABILITY OF BEING IN AN ALTITUDE INTERVAL, HP, WHEN R EXHIBITS A PEAK
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.90
1.x10+00
1.x10-01
1.x10-02
1.x10-03
1.x10-04
HP
0
5000.
10000.
15000.
20000.
25000.
30000.
35000.
40000.
45000.
50000.
ALTITUDE, HP (FEET)
TOTAL NO. OF PEAKS = 7563.
PEAKING VARIABLE (R)
CASE NO. 63

Figure 16

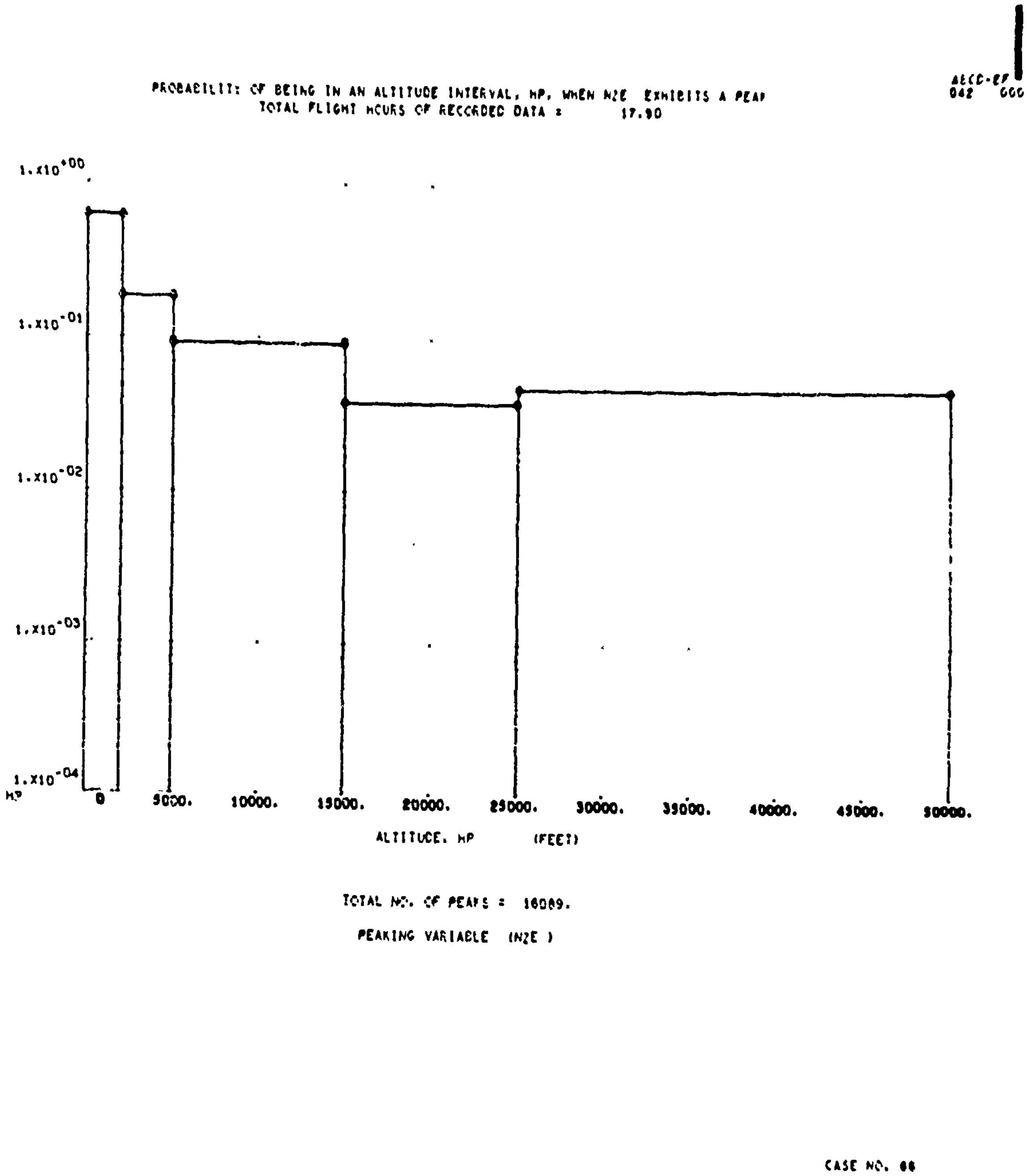

PROBABILITY OF BEING IN AN ALTITUDE INTERVAL, HP, WHEN NZE EXHIBITS A PEAK
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.90
1.x10+00
1.x10-01
1.x10-02
1.x10-03
1.x10-04
HP
0
5000.
10000.
15000.
20000.
25000.
30000.
35000.
40000.
45000.
50000.
ALTITUDE, HP (FEET)
TOTAL NO. OF PEAKS = 16089.
PEAKING VARIABLE (NZE)
CASE NO. 66

Figure 17

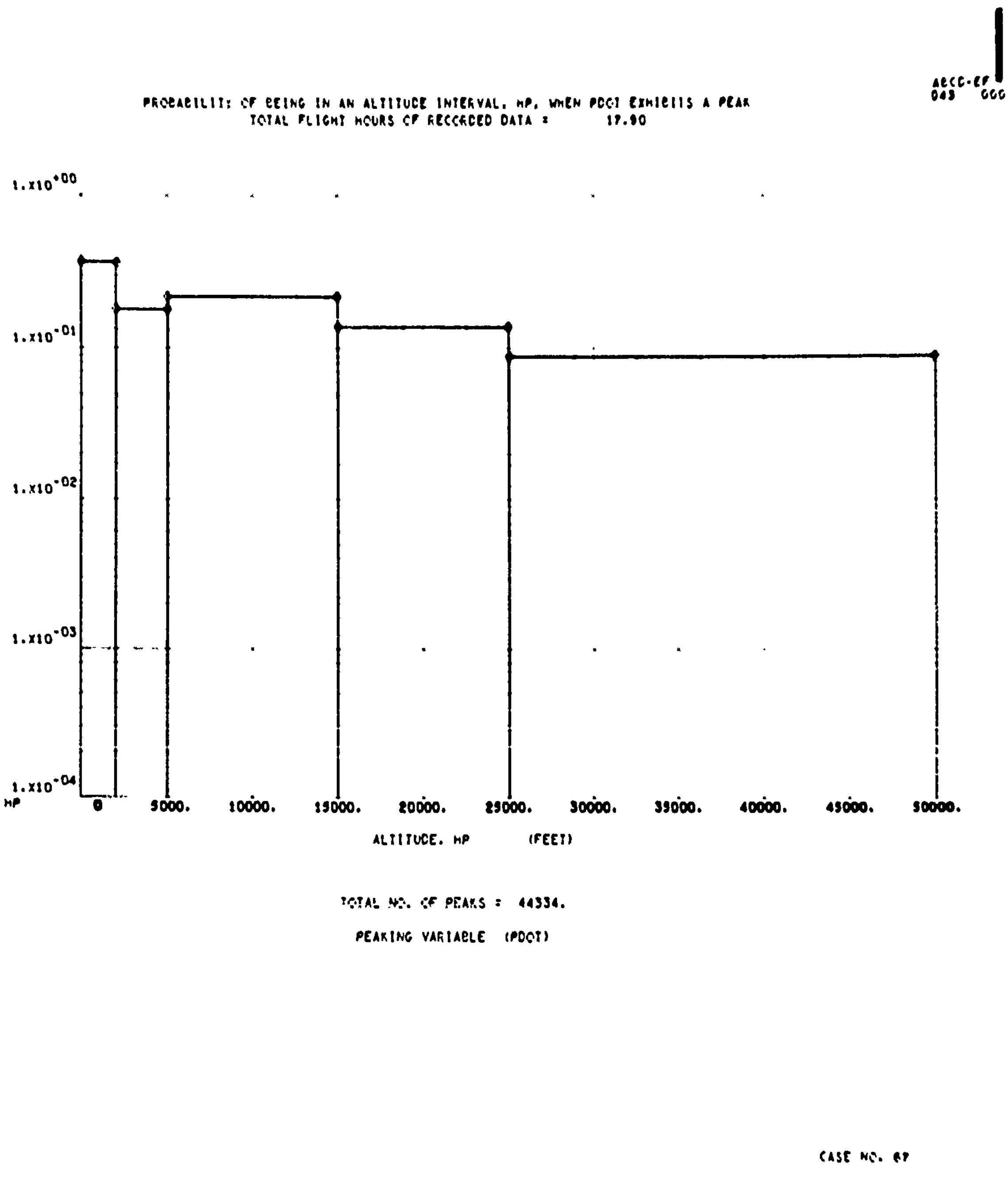
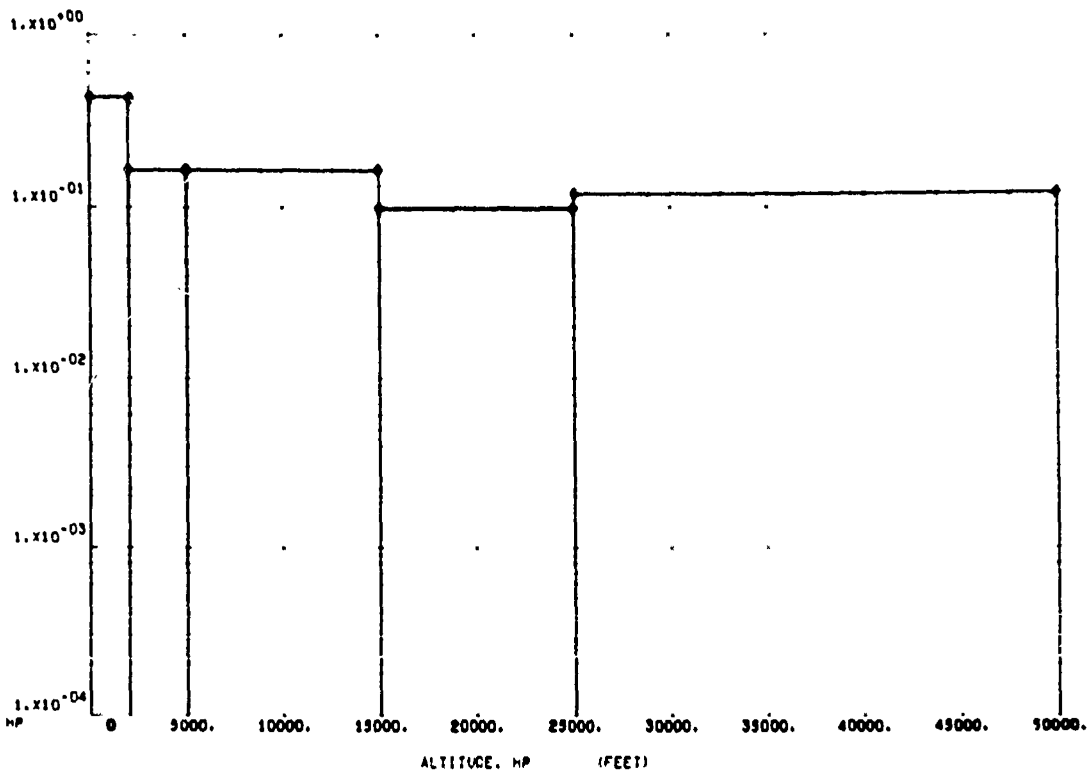

AECC-EF
043 000
PROBABILITY OF BEING IN AN ALTITUDE INTERVAL, HP, WHEN PDOT EXHIBITS A PEAK
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.90
1.x10+00
1.x10-01
1.x10-02
1.x10-03
1.x10-04
HP
0
5000.
10000.
15000.
20000.
25000.
30000.
35000.
40000.
45000.
50000.
ALTITUDE, HP (FEET)
TOTAL NO. OF PEAKS = 44334.
PEAKING VARIABLE (PDOT)
CASE NO. 67

Figure 18

AECC-EF
044 000

PROBABILITY OF BEING IN AN ALTITUDE INTERVAL, HP, WHEN QDOT EXHIBITS A PEAK
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.90



TOTAL NO. OF PEAKS = 114397.

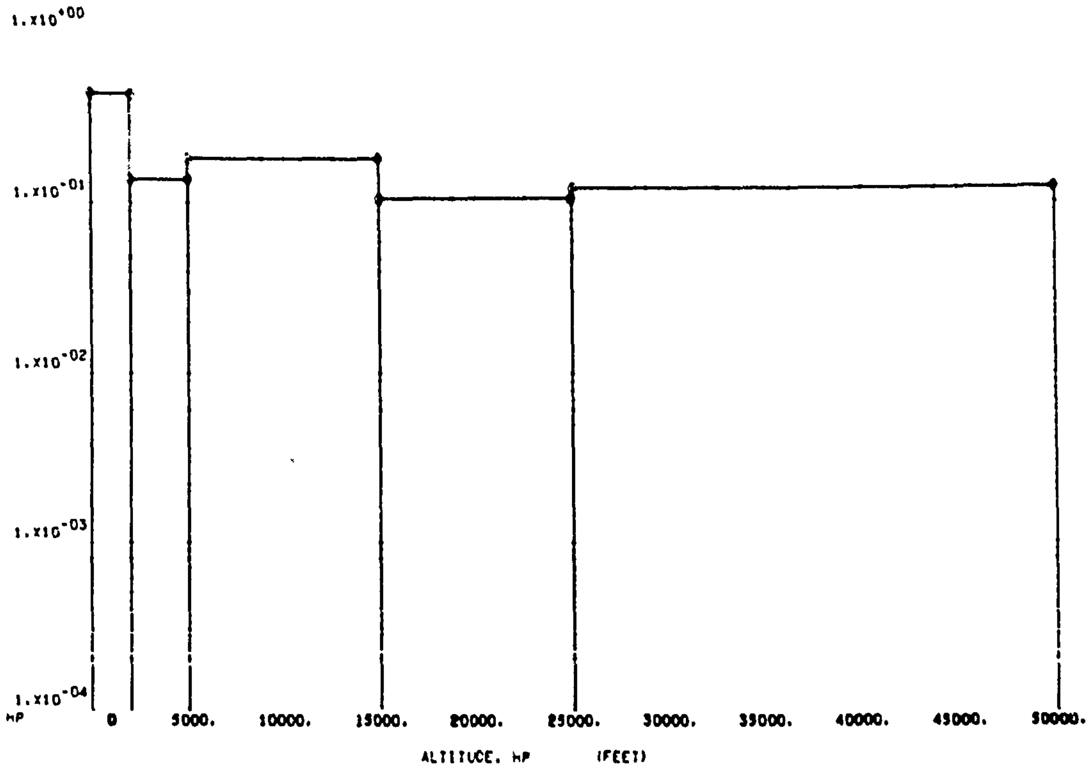
PEAKING VARIABLE (QDOT)

CASE NO. 68

Figure 19

ABCD-EF
045 000

PROBABILITY OF BEING IN AN ALTITUDE INTERVAL, HP, WHEN RDOT EXHIBITS A PEAK
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.90



TOTAL NO. OF PEAKS = 75654.

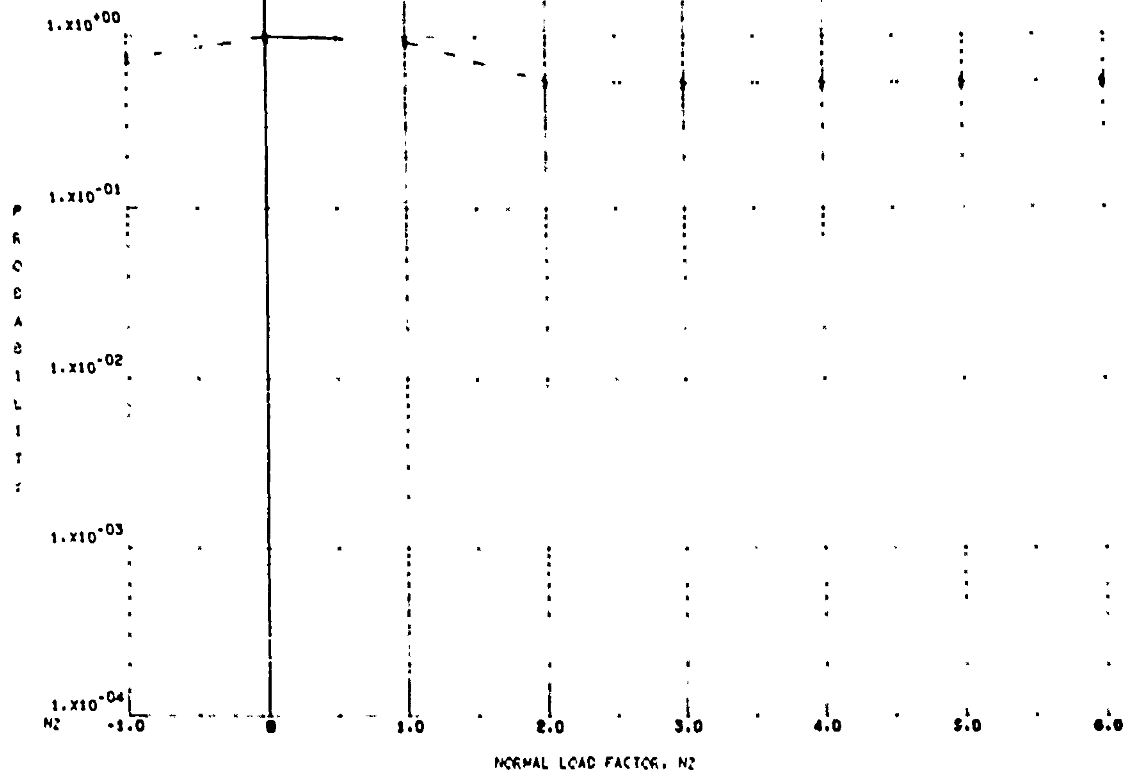
PEAKING VARIABLE (RDOT)

CASE NO. 69

Figure 20

ABCD-EF
000 000

PROBABILITY OF VARIABLE'S PEAK EXCEEDING A VALUE OF THE VARIABLE (NZ)
GIVEN THE INTERVALS OF W , VE, AND HP
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.90



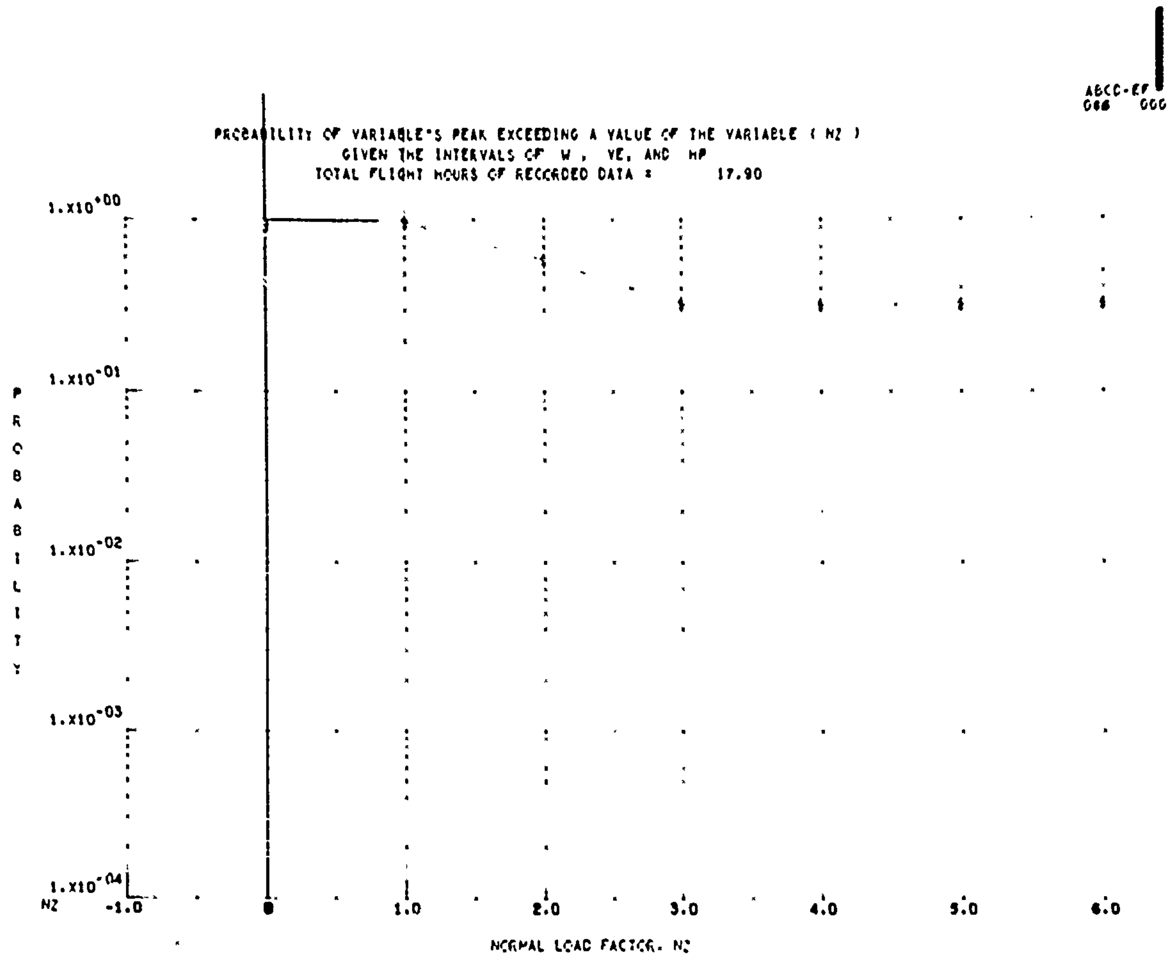
	WEIGHT, W, (POUNDS)			NO. OF PEAKS. (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	4675.	4.	4671.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 1, FROM 0. TO 250. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 1, FROM 0. TO 2000. (FEET)

CASE NO. 12

Figure 21



	WEIGHT, W. (POUNDS)			NO. OF PEAKS. (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	395.	0.	395.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

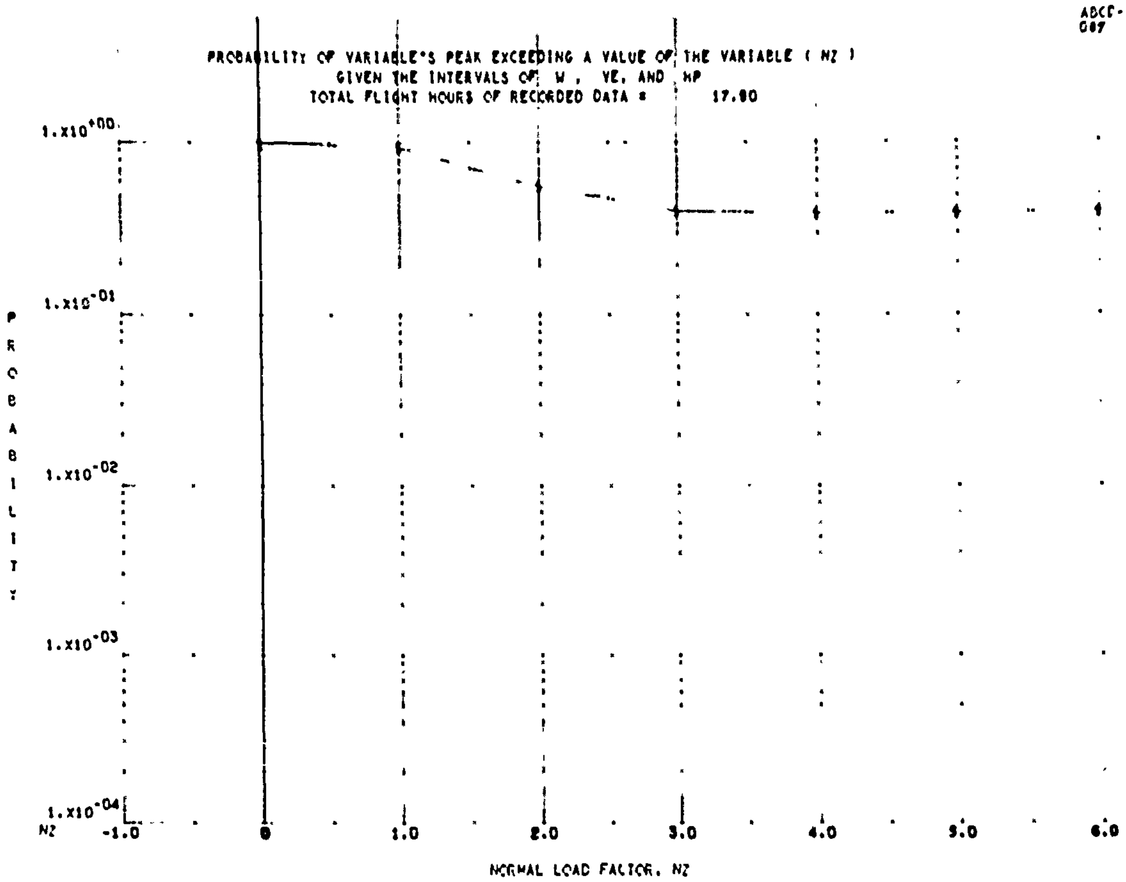
VELOCITY, VE, INTERVAL NO. 2, FROM 250. TO 300. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 1, FROM 0. TO 2000. (FEET)

CASE NO. 12

Figure 22

ABCC-EF
087 000



	WEIGHT, W. (POUNDS)			NO. OF PEAKS. (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	699.	2.	697.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 3, FROM 300. TO 350. (KNOTS)

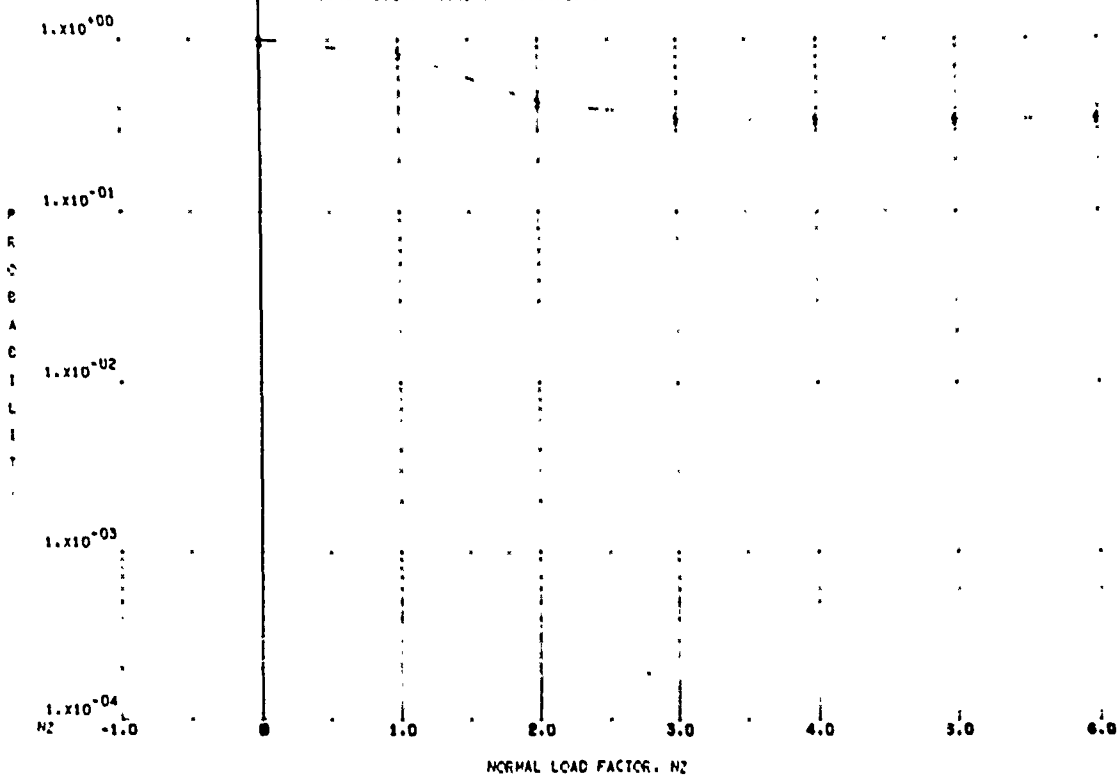
ALTITUDE, HP, INTERVAL NO. 1, FROM 0. TO 2000. (FEET)

CASE NO. 18

Figure 23

ABCD-EF
008 000

PROBABILITY OF VARIABLE'S PEAK EXCEEDING A VALUE OF THE VARIABLE (NZ)
GIVEN THE INTERVALS OF W , VE, AND HP
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.80



	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	696.	3.	693.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 4, FROM 350. TO 400. (KNOTS)

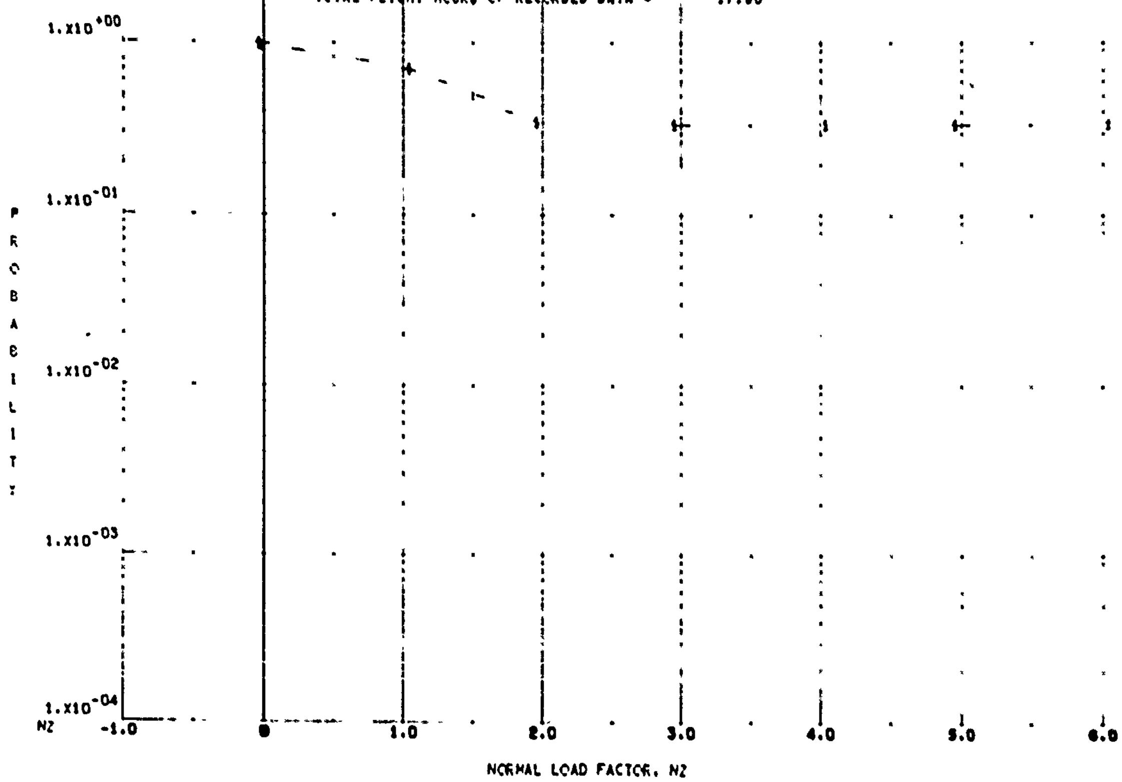
ALTITUDE, HP, INTERVAL NO. 1, FROM 0. TO 2000. (FEET)

CASE NO. 12

Figure 24

ABCC-EF
000 000

PROBABILITY OF VARIABLE'S PEAK EXCEEDING A VALUE OF THE VARIABLE (NZ)
GIVEN THE INTERVALS OF W , VE, AND HP
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.80



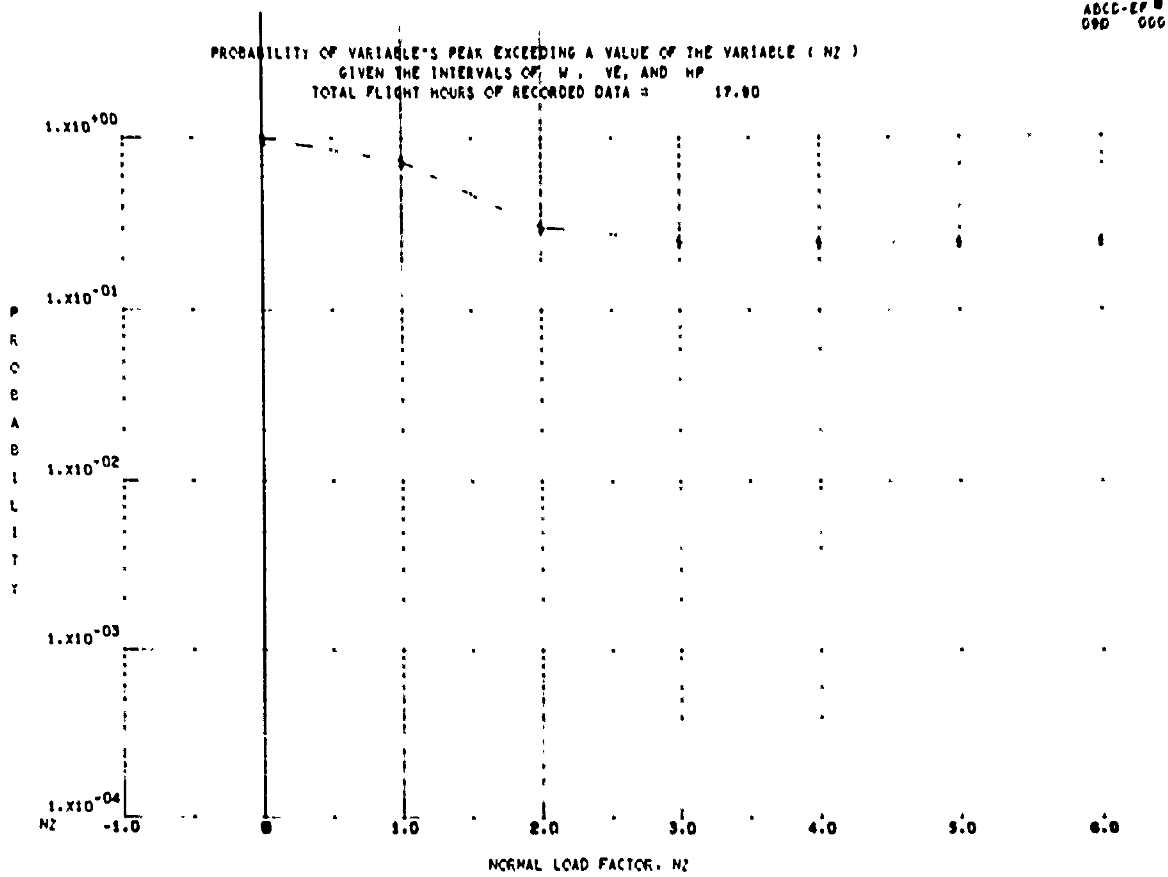
	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	104.	3.	101.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 5, FROM 400. TO 450. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 1, FROM 0. TO 2000. (FEET)

CASE NO. 12

Figure 25



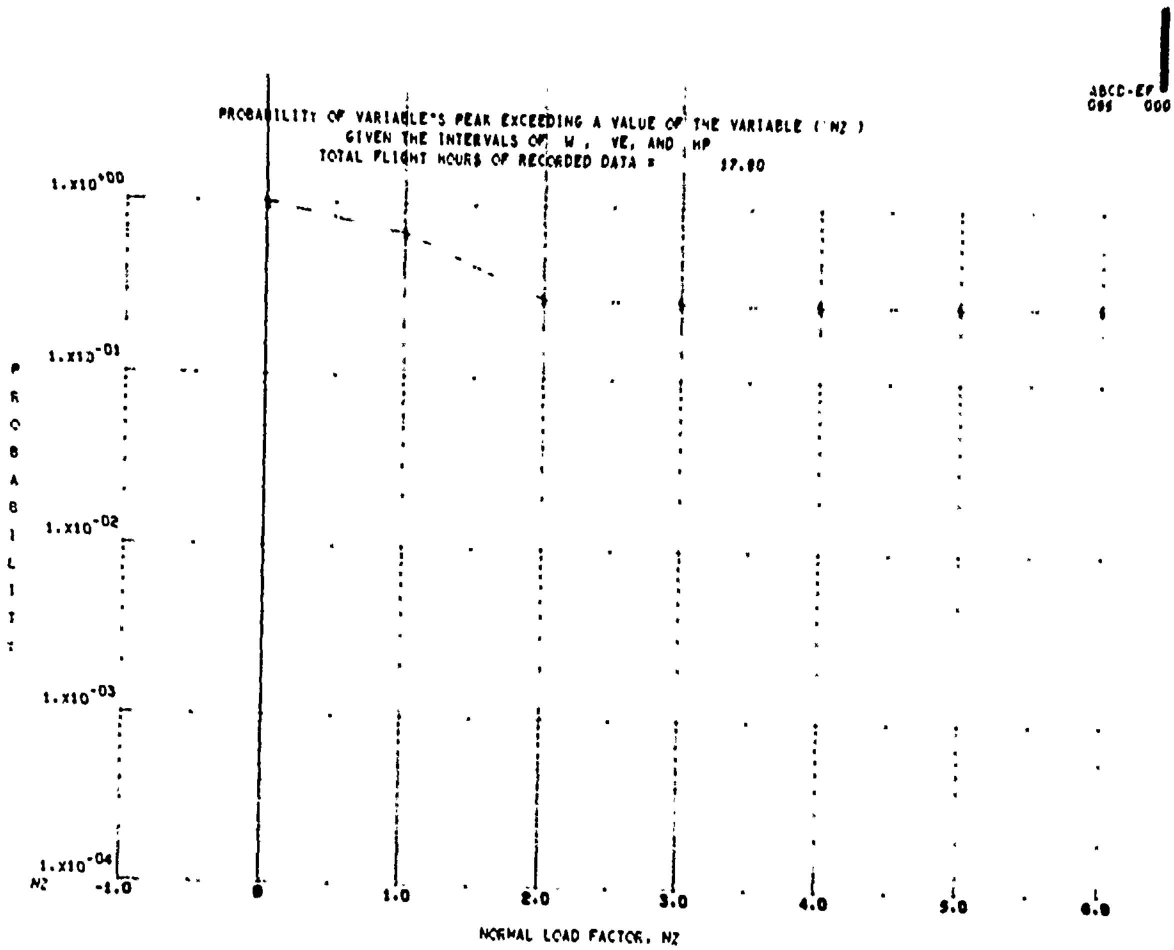
	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	298.	8.	290.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 6, FROM 450. TO 500. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 1, FROM 0. TO 2000. (FEET)

CASE NO. 12

Figure 26



SYMBOL	WEIGHT, W, (POUNDS) INT.NO.	FROM	TO	NO. OF PEAKS, (NZ) TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	2806.	43.	2763.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

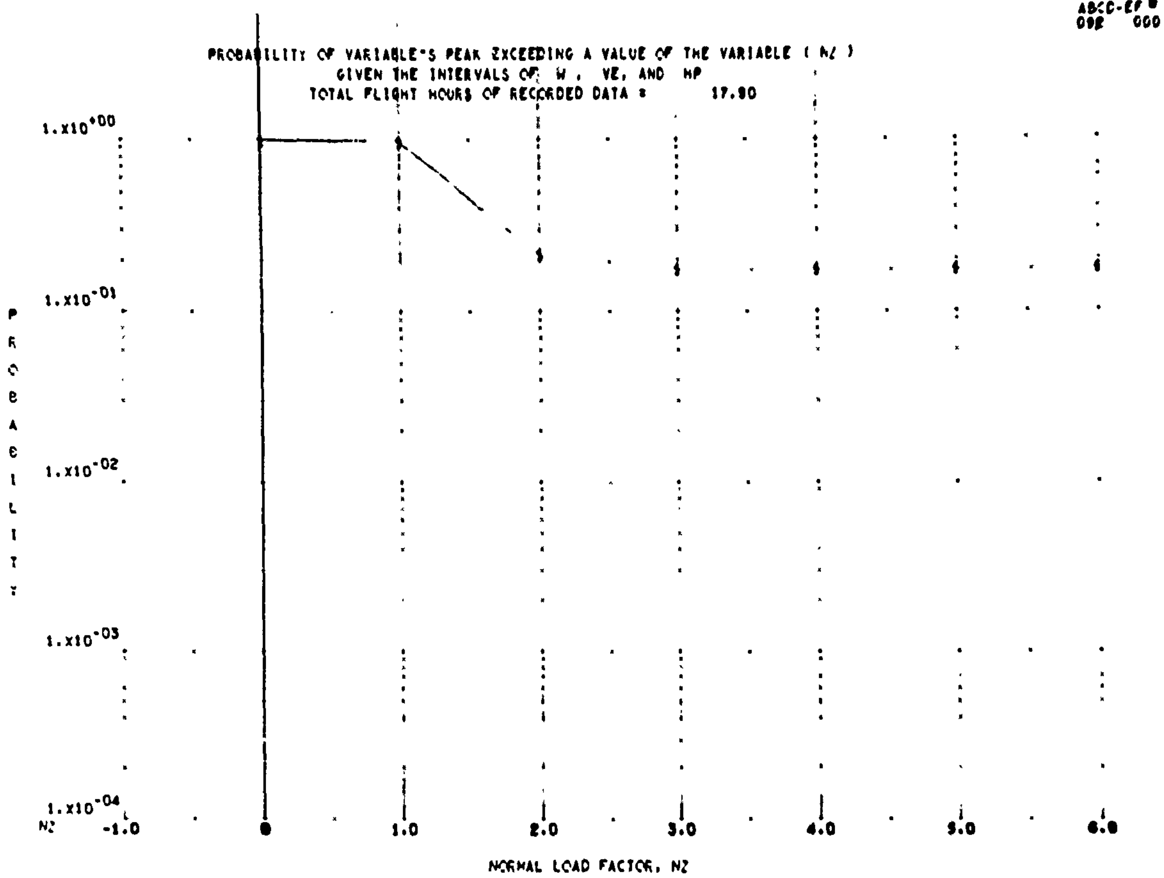
VELOCITY, VE, INTERVAL NO. 7, FROM 500. TO 600. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 1, FROM 0. TO 2000. (FEET)

CASE NO. 12

Figure 27

PROBABILITY OF VARIABLE'S PEAK EXCEEDING A VALUE OF THE VARIABLE (NZ)
GIVEN THE INTERVALS OF W , VE, AND HP
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.80



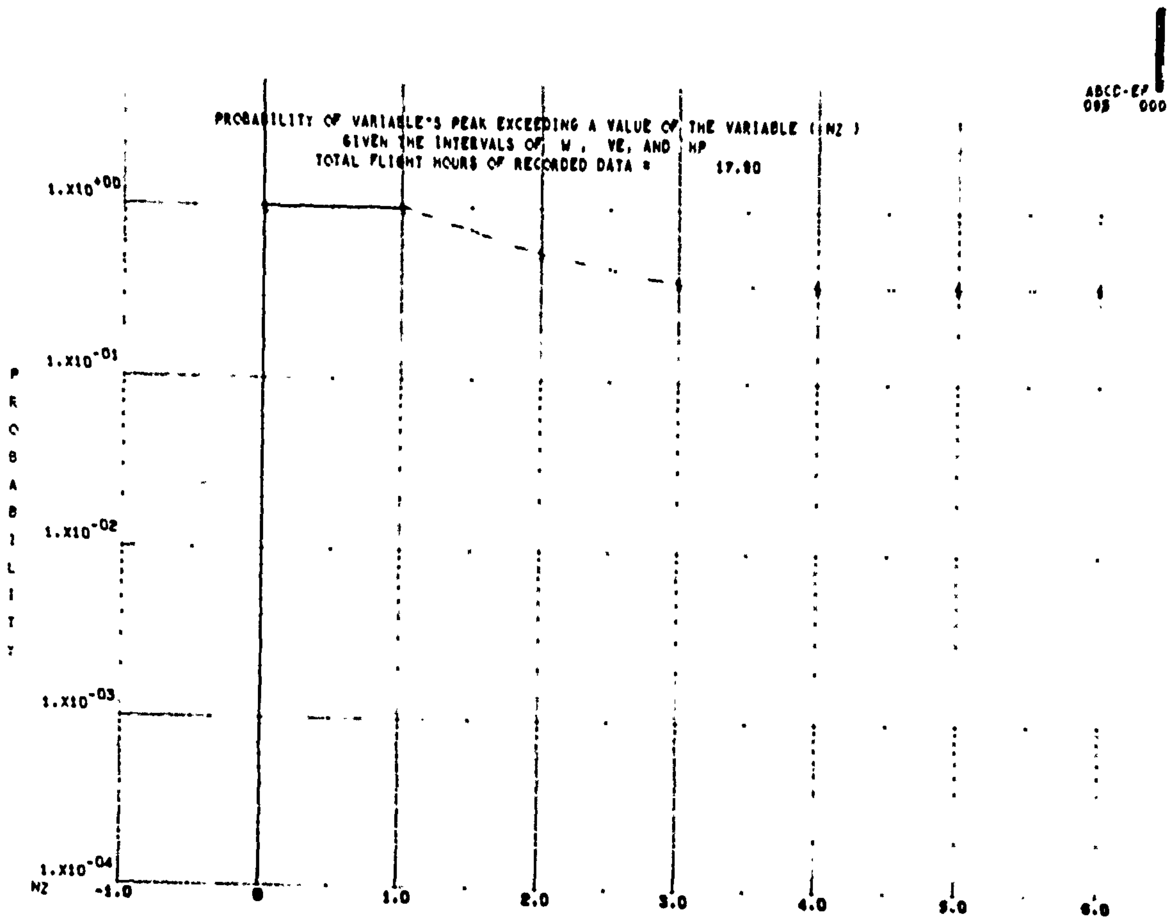
WEIGHT, W. (POUNDS)				NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	109.	0.	109.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 1, FROM 0. TO 250. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 2, FROM 2000. TO 5000. (FEET)

CASE NO. 12

Figure 28



	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	165.	0.	165.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 2, FROM 250. TO 300. (KNOTS)

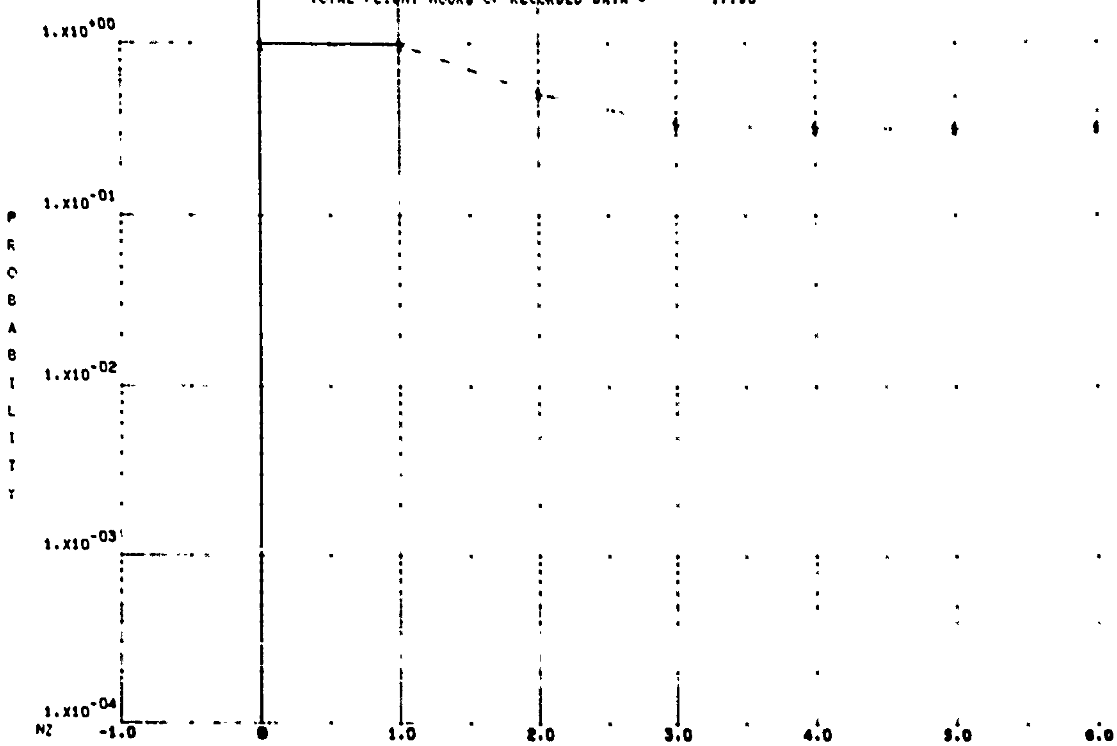
ALTITUDE, HP, INTERVAL NO. 2, FROM 2000. TO 5000. (FEET)

CASE NO. 12

Figure 29

ABCC-CF
094 000

PROBABILITY OF VARIABLE'S PEAK EXCEEDING A VALUE OF THE VARIABLE (NZ)
GIVEN THE INTERVALS OF W , VE, AND HP
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.80



NORMAL LOAD FACTOR, NZ

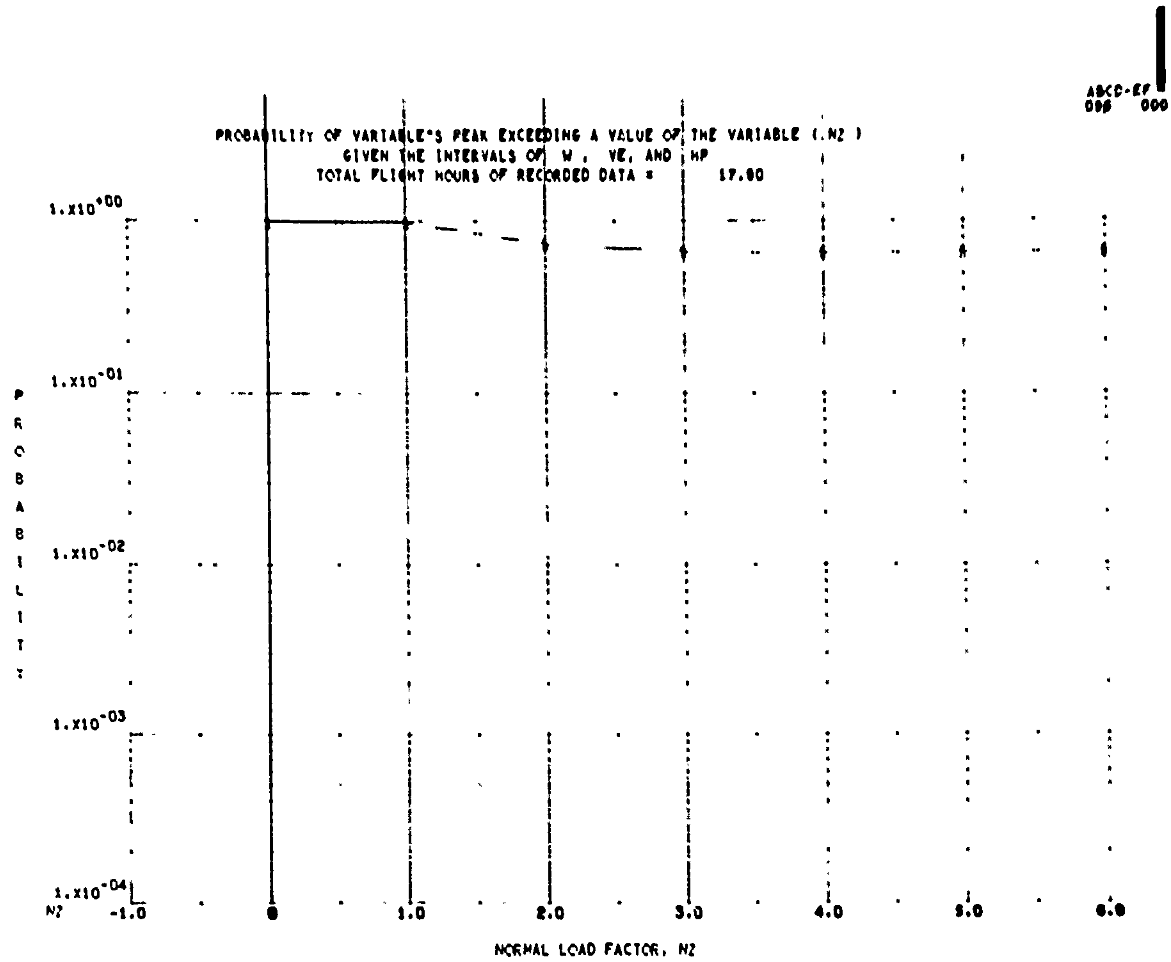
	WEIGHT, W, (POUNDS)			NO. OF PEAKS. (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	225.	0.	225.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 3, FROM 300. TO 350. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 2, FROM 2000. TO 5000. (FEET)

CASE NO. 12

Figure 30



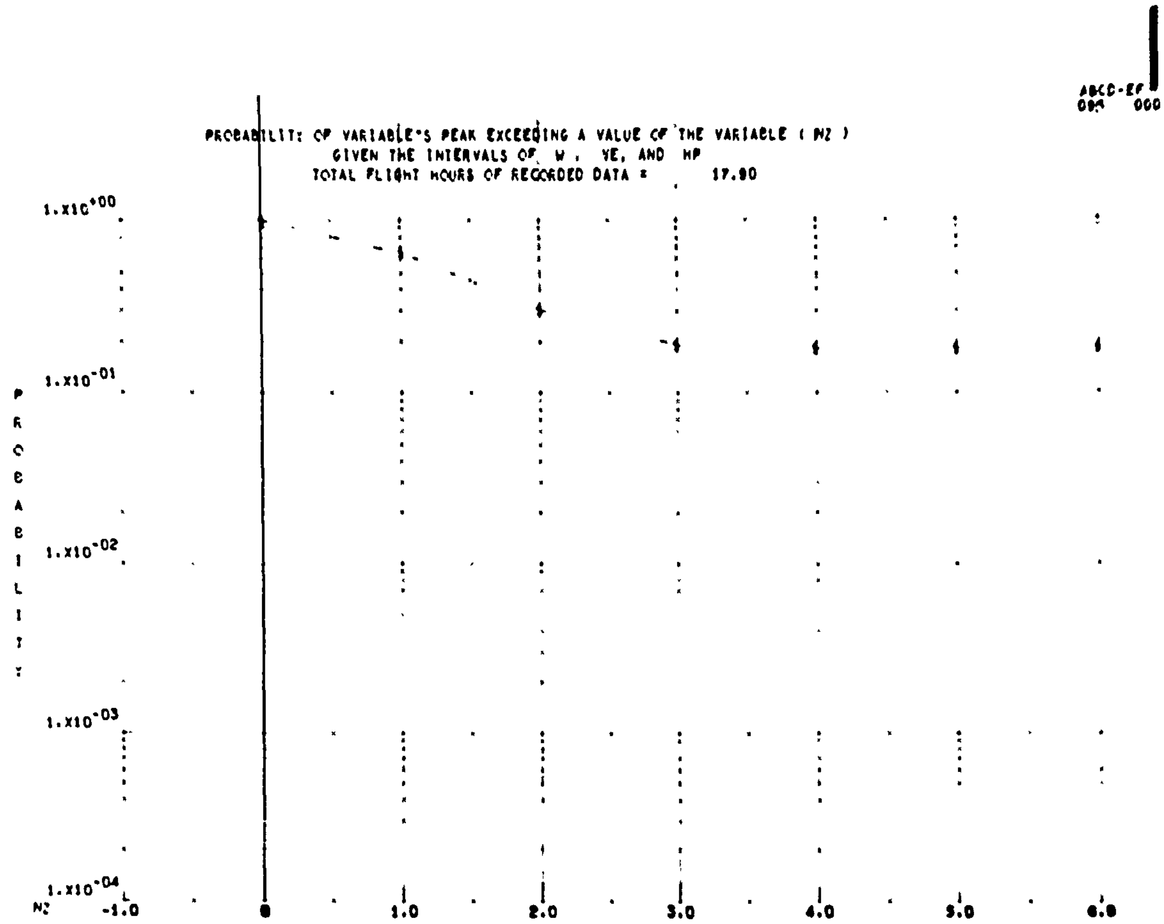
SYMBOL	WEIGHT, W, (POUNDS) INT.NO.	FROM	TO	NO. OF PEAKS, (NZ) TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	293.	0.	293.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 4, FROM 350. TO 400. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 2, FROM 2000. TO 5000. (FEET)

CASE NO. 12

Figure 31



WEIGHT, W. (POUNDS)				NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	204.	4.	200.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

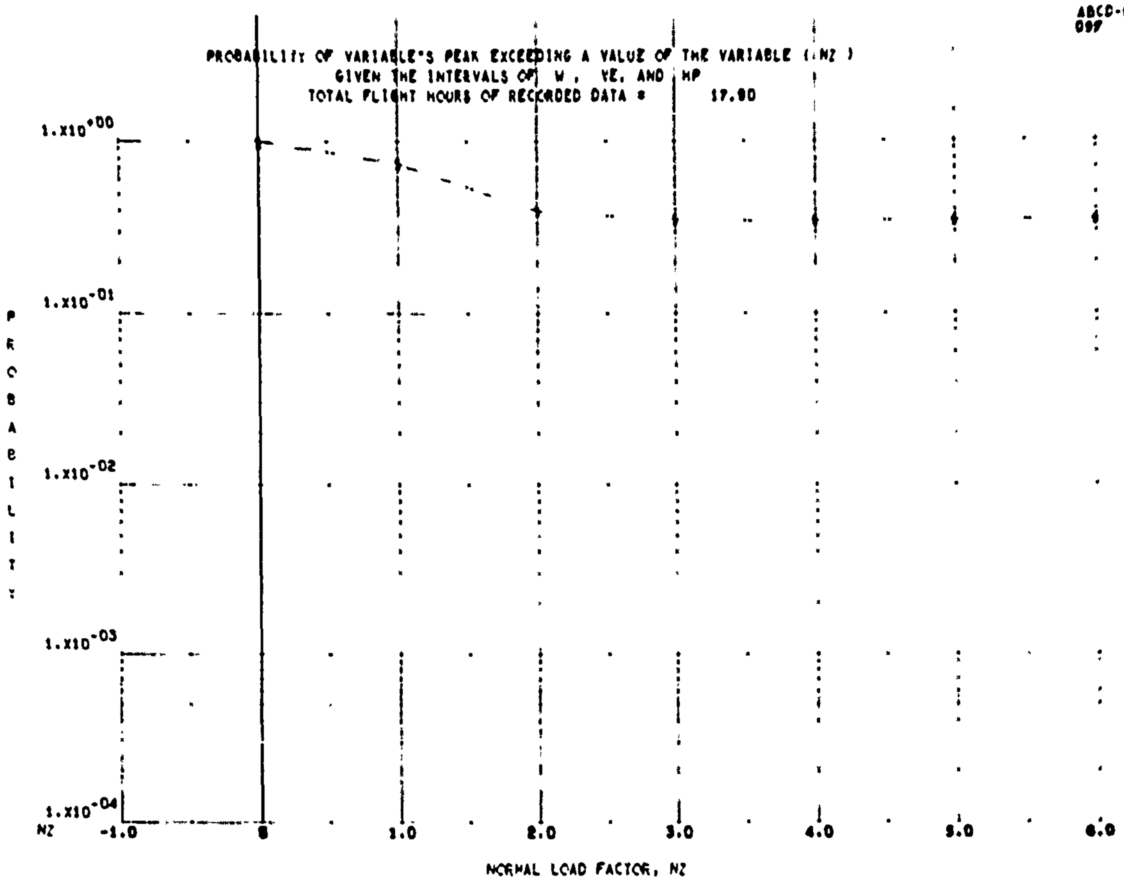
VELOCITY, VE, INTERVAL NO. 5, FROM 400. TO 450. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 2, FROM 2000. TO 5000. (FEET)

CASE NO. 18

Figure 32

ABCD-EF
097 000



	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	821.	10.	811.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 6, FROM 450. TO 500. (KNOTS)

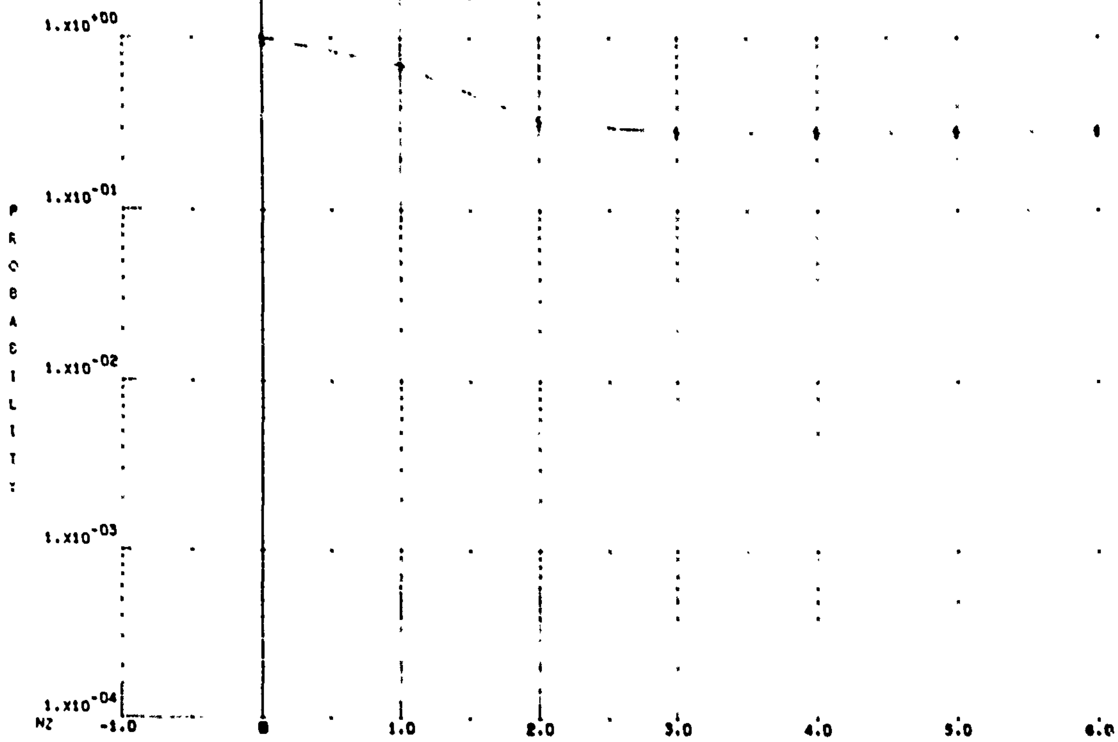
ALTITUDE, HP, INTERVAL NO. 2, FROM 2000. TO 5000. (FEET)

CASE NO. 12

Figure 33

ABCD-EF
G00 GGG

PROBABILITY OF VARIABLE'S PEAK EXCEEDING A VALUE OF THE VARIABLE (NZ)
GIVEN THE INTERVALS OF W , VE, AND HP
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.90



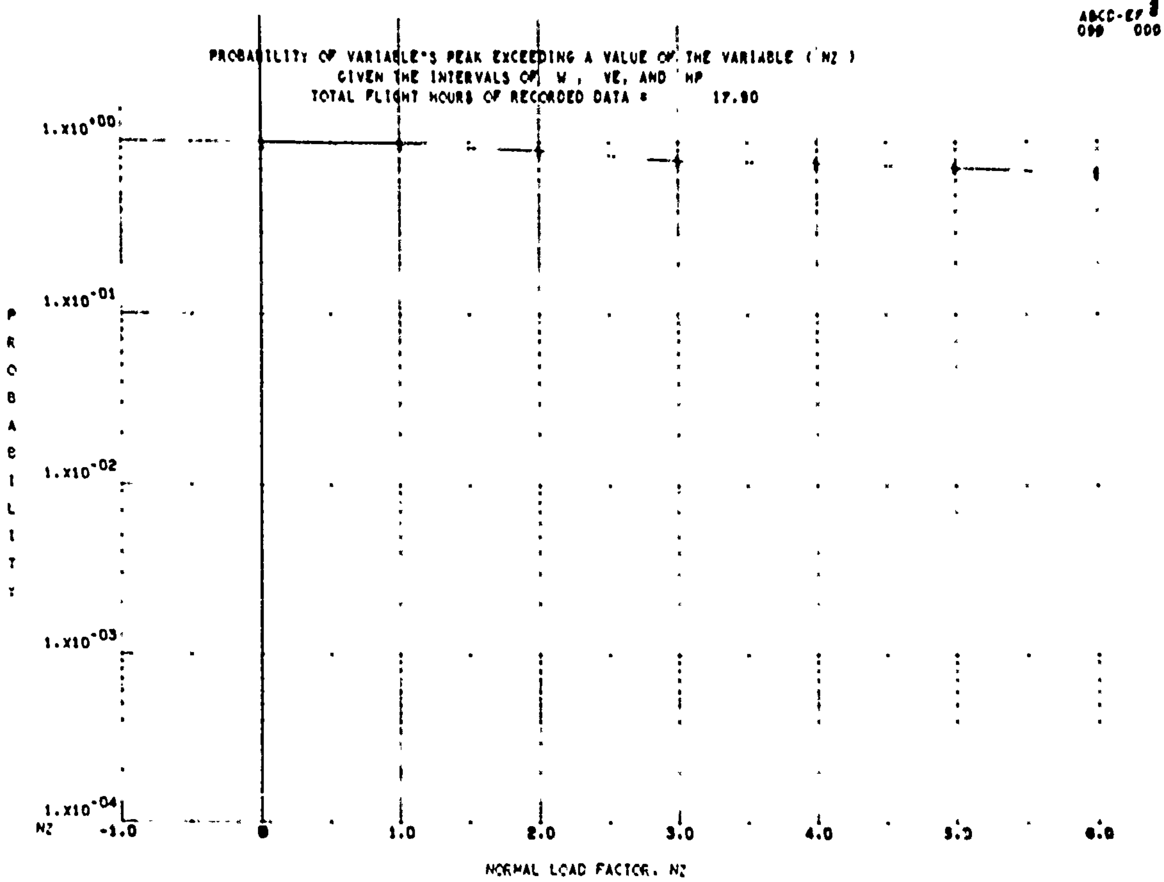
	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	1454.	37.	1417.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 7, FROM 500. TO 600. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 2, FROM 2000. TO 5000. (FEET)

CASE NO. 12

Figure 34



	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	97.	0.	97.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

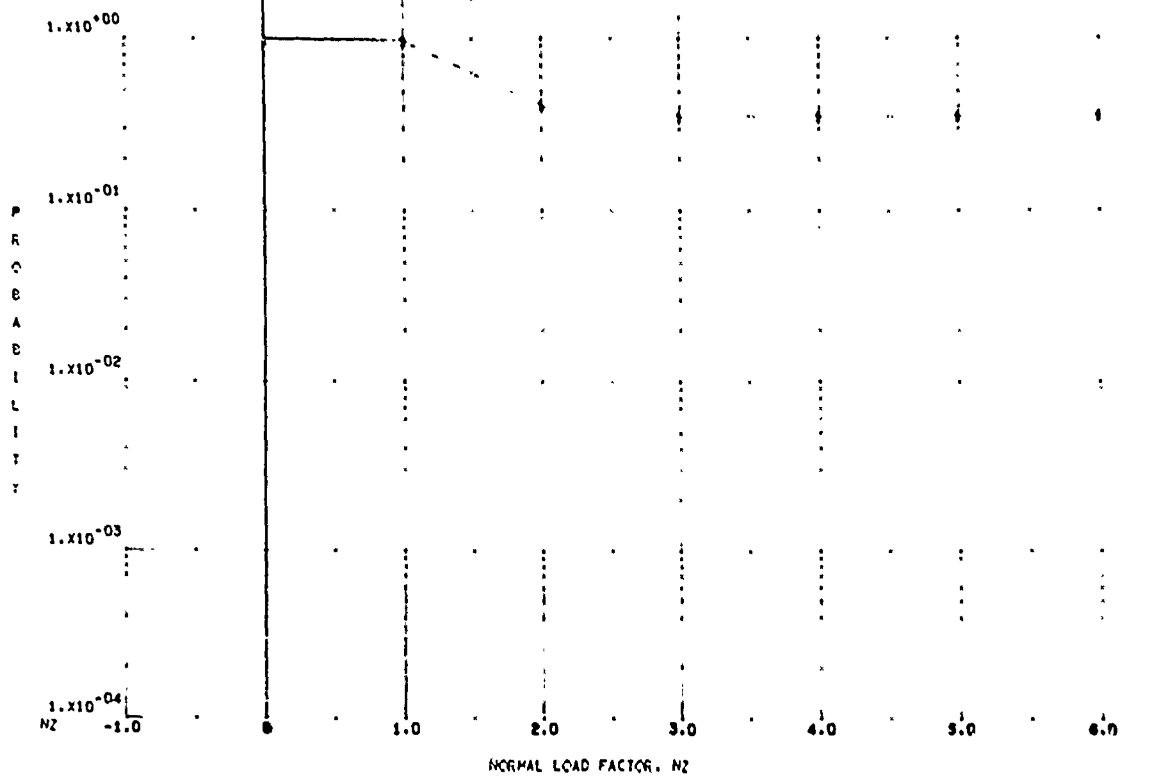
VELOCITY, VE, INTERVAL NO. 8, FROM 600. TO 610. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 2, FROM 2000. TO 5000. (FEET)

CASE NO. 12

Figure 35

PROBABILITY OF VARIABLE'S PEAK EXCEEDING A VALUE OF THE VARIABLE (NZ)
GIVEN THE INTERVALS OF W , VE, AND HP
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.90



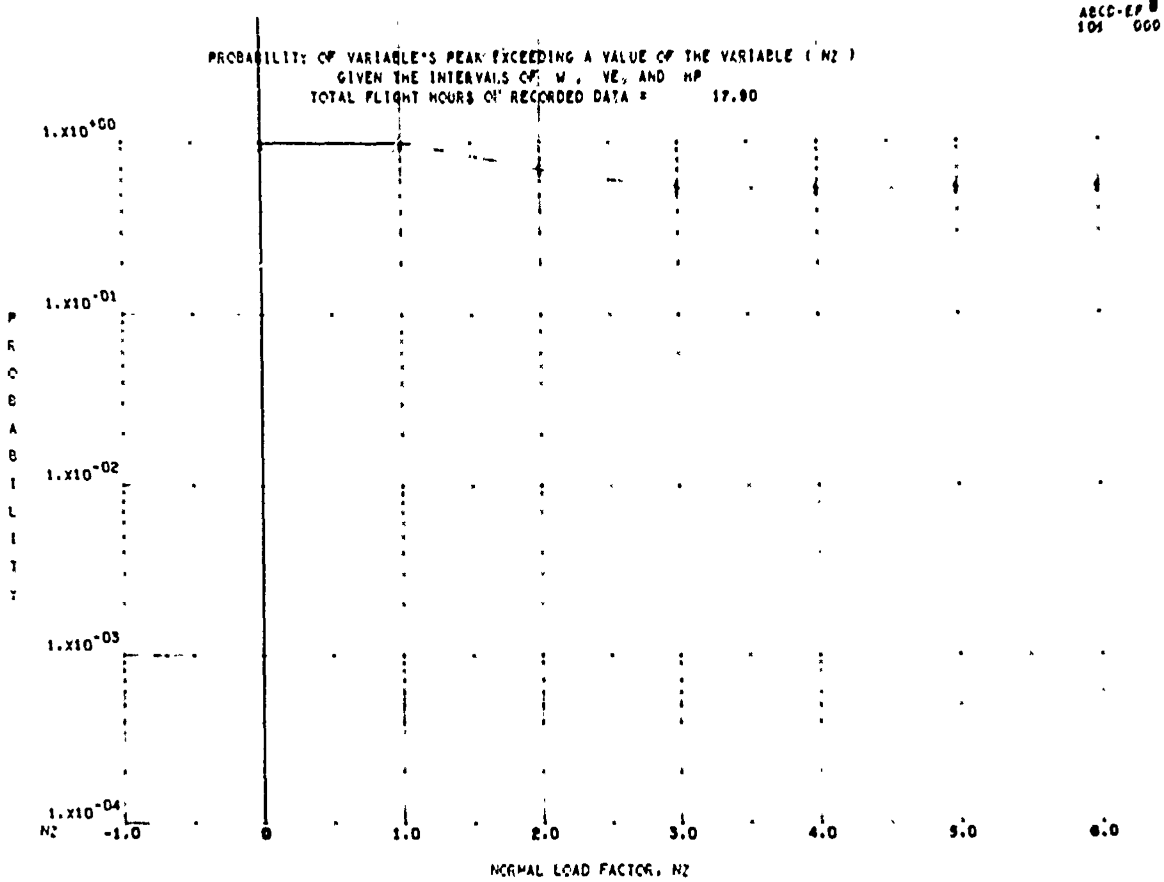
	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	37.	0.	37.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 1, FROM 0. TO 250. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 3, FROM 5000. TO 15000. (FEET)

CAL. NO. 12

Figure 36



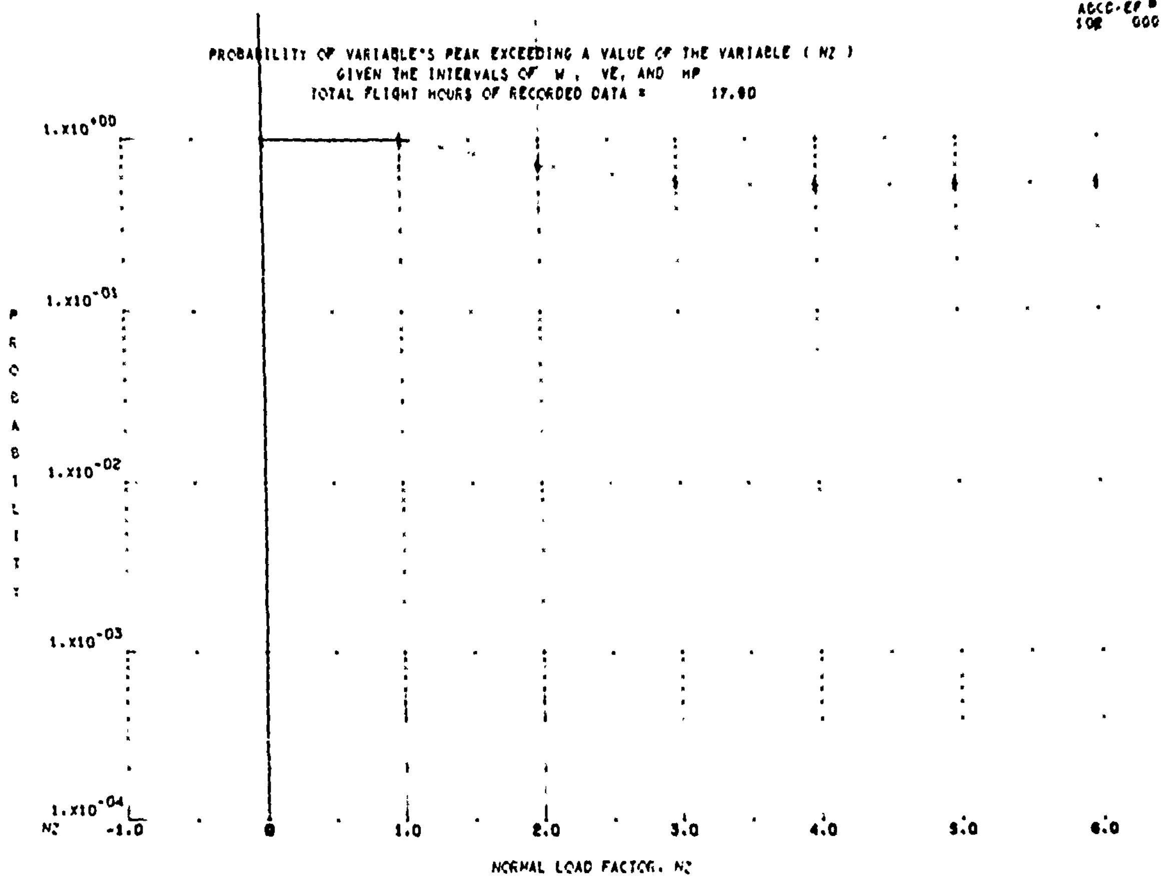
SYMBOL	INT.NO.	WEIGHT, W, (POUNDS) FROM	TO	NO. OF PEAKS, (NZ) TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	174.	0.	174.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 2, FROM 250. TO 300. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 3, FROM 5000. TO 15000. (FEET)

CASE NO. 12

Figure 37



	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	495.	0.	495.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

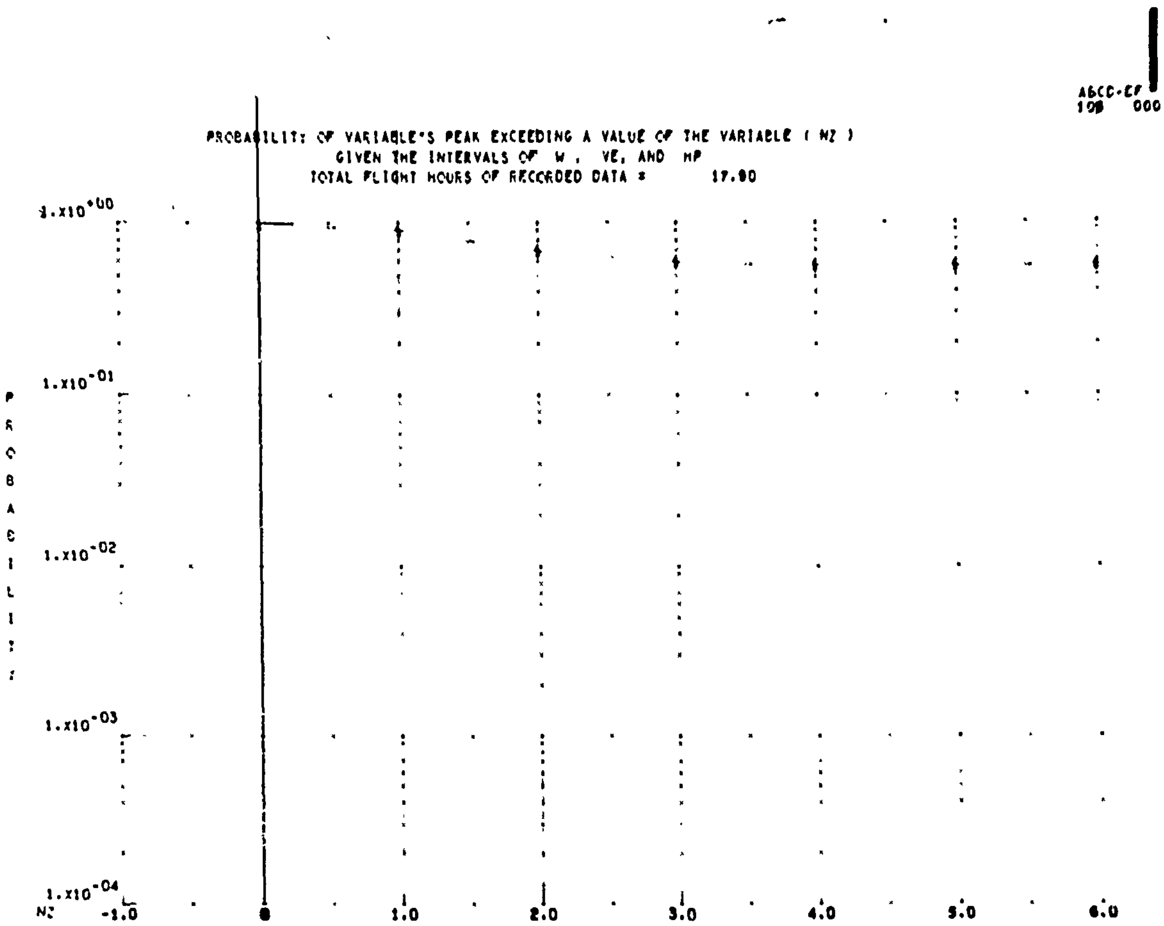
VELOCITY, VE, INTERVAL NO. 3. FROM 300. TO 350. (KNOTS)

ALTITUDE, HP. INTERVAL NO. 3. FROM 5000. TO 15000. (FEET)

CASE NO. 18

Figure 38

PROBABILITY OF VARIABLE'S PEAK EXCEEDING A VALUE OF THE VARIABLE (NZ)
GIVEN THE INTERVALS OF W , VE, AND HP
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.80



NORMAL LOAD FACTOR, NZ

	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	367.	0	367.
2	2	35000.	40000.	0.	0	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

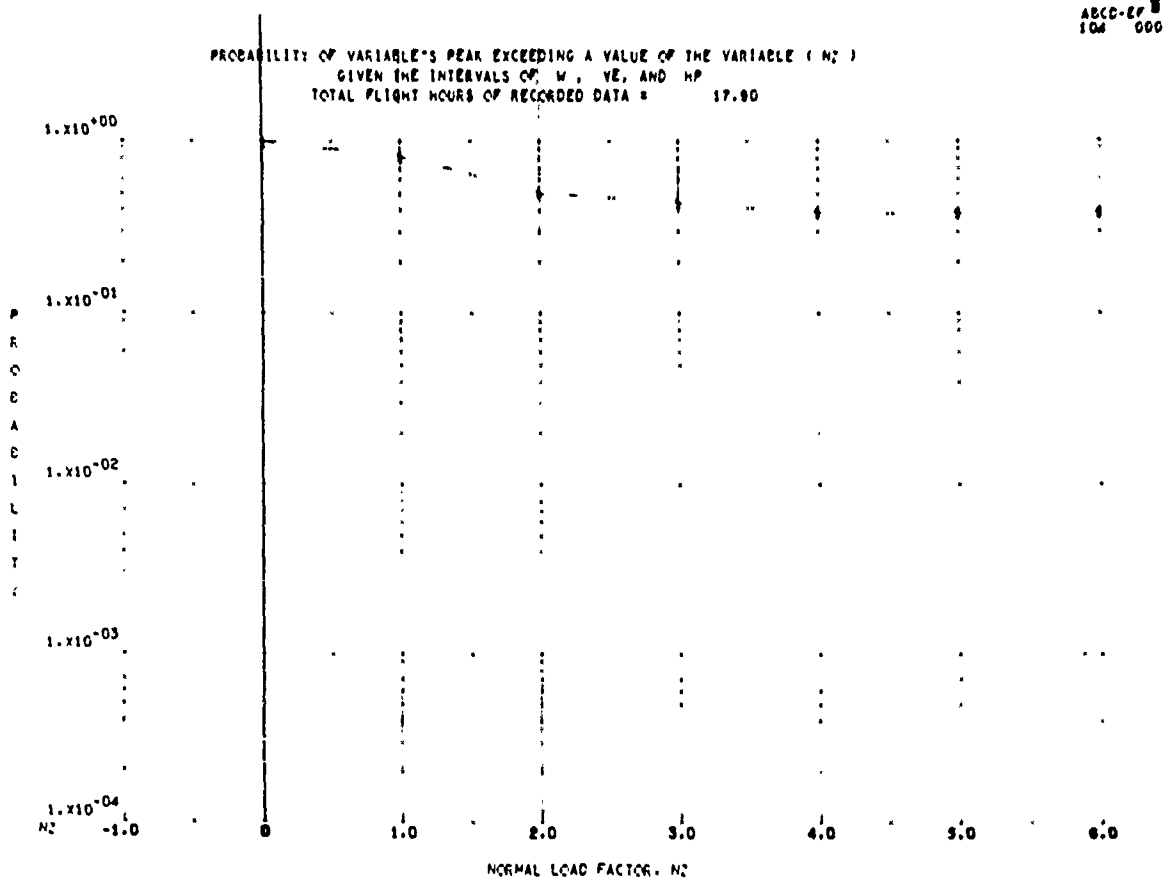
VELOCITY, VE, INTERVAL NO. 4 FROM 350. TO 400. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 1 FROM 5000. TO 15000. (FEET)

CASE NO. 18

Figure 39

ABCD-EF
104 000



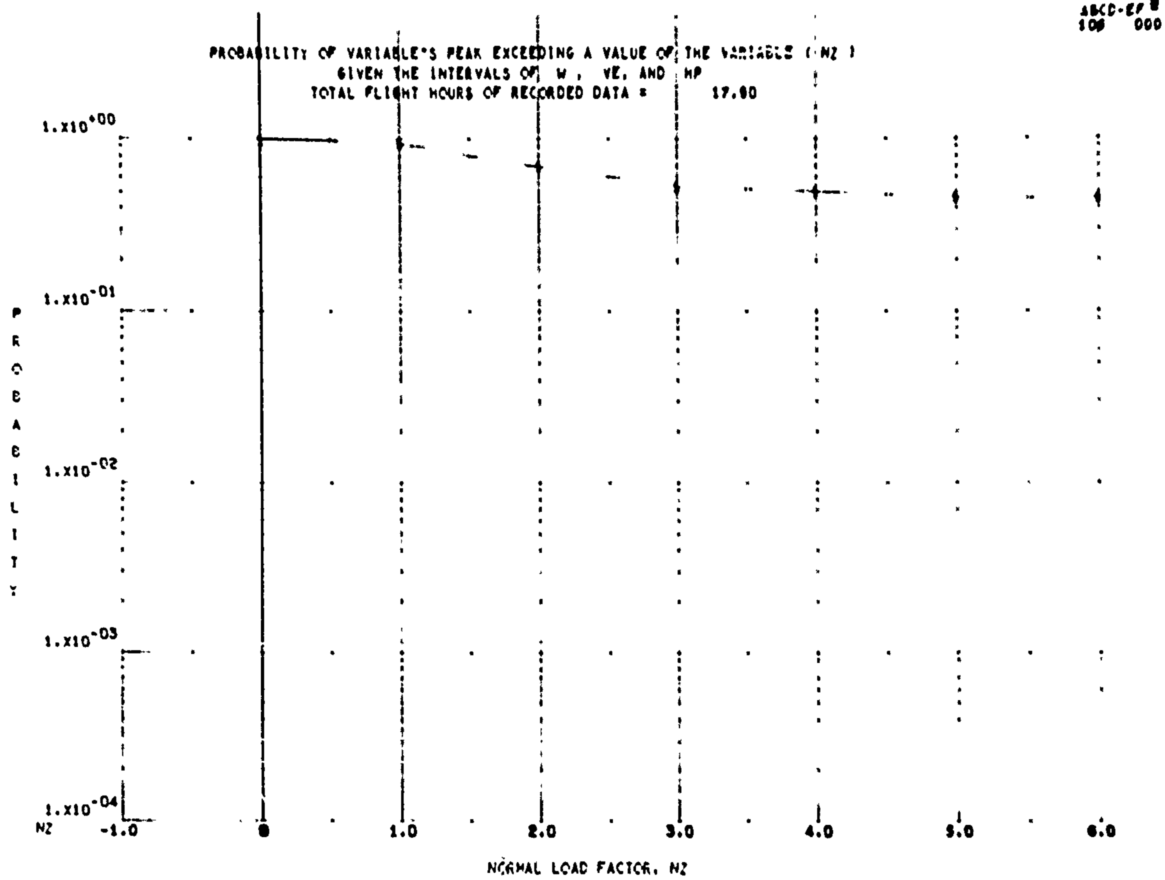
	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	306.	0.	306.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 5, FROM 400. TO 450. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 3, FROM 5000. TO 15000. (FEET)

CASE NO. 12

Figure 40



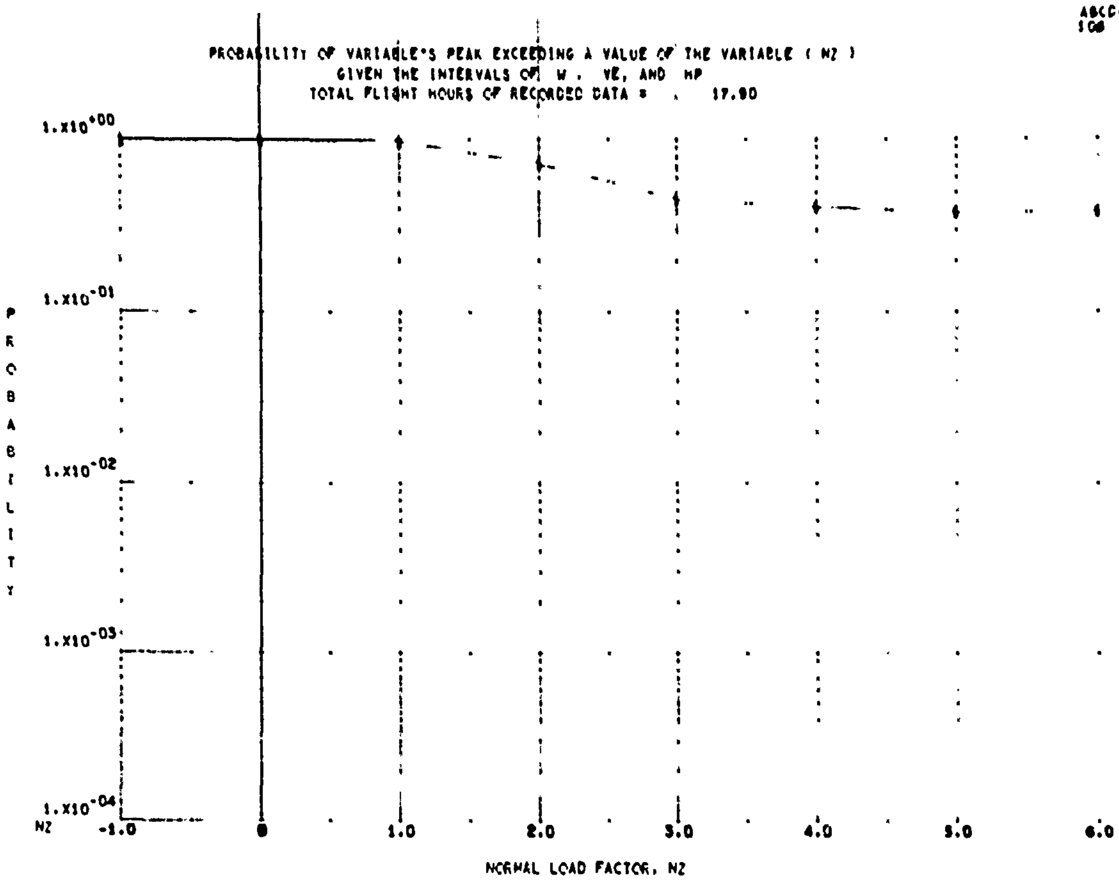
WEIGHT, W, (POUNDS)				NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	96.	0.	96.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 6, FROM 450. TO 500. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 3, FROM 5000. TO 15000. (FEET)

CASE NO. 12

Figure 41



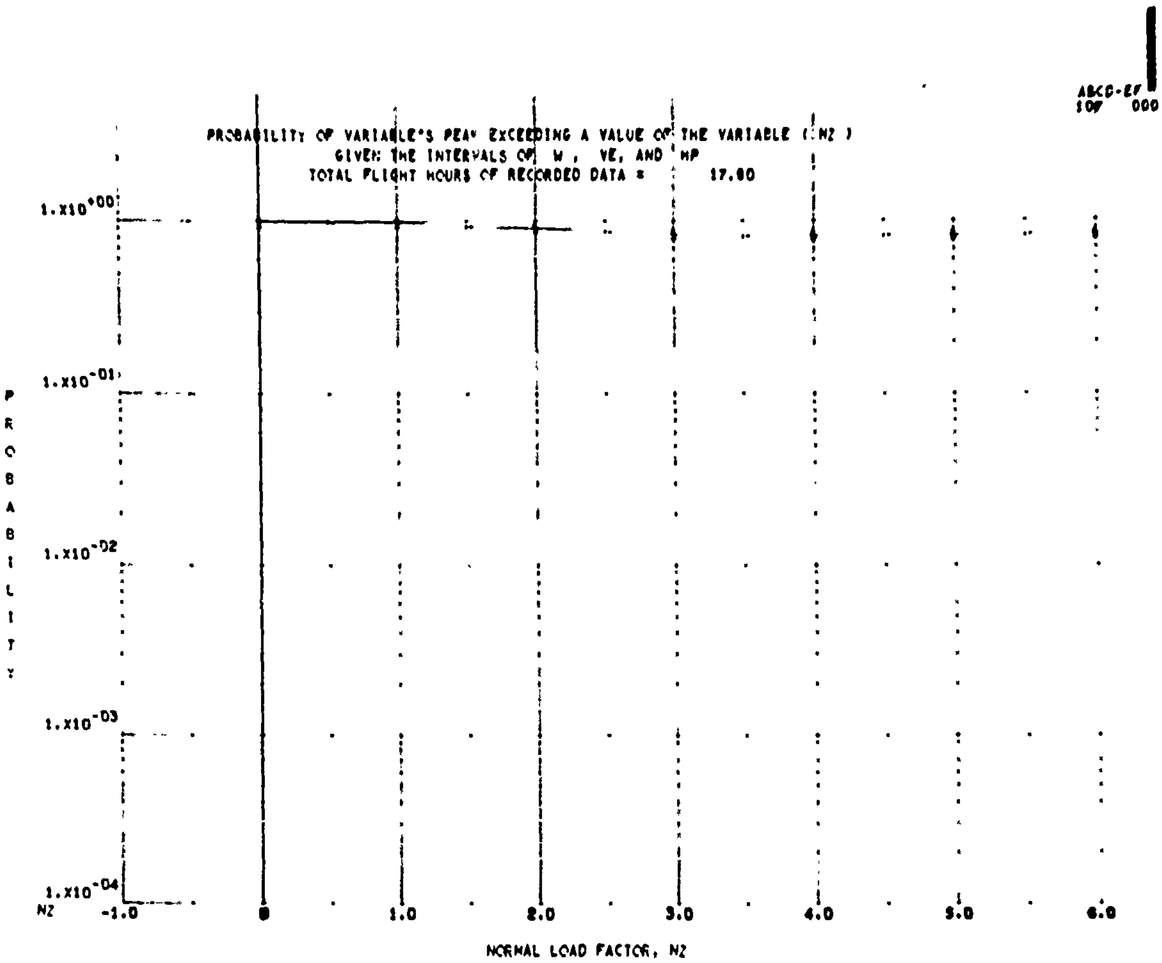
	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	154.	2.	152.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 7, FROM 500. TO 600. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 3, FROM 5000. TO 15000. (FEET)

CASE NO. 12

Figure 42



	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	140.	0.	140.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

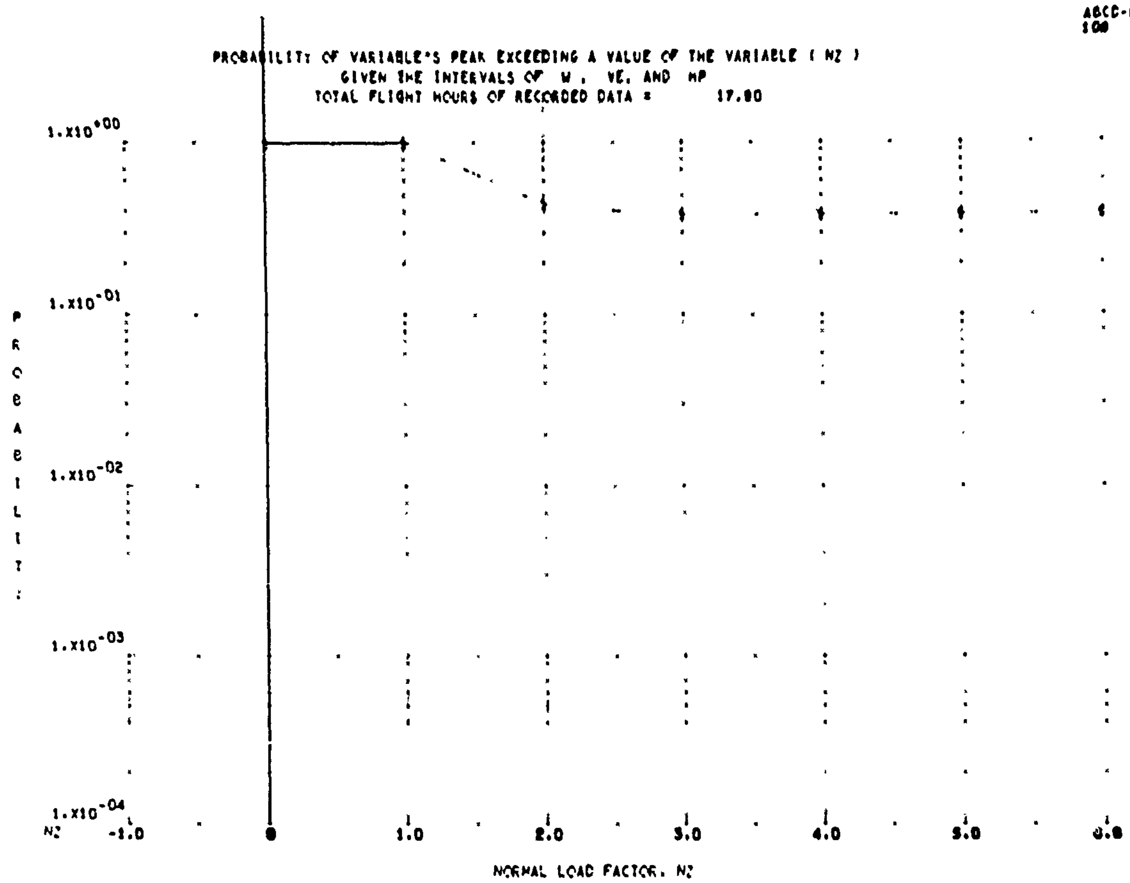
VELOCITY, VE, INTERVAL NO. 8, FROM 800. TO 810. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 3, FROM 5000. TO 15000. (FEET)

CASE NO. 12

Figure 43

ABCD-EF
100 000



	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	122.	0.	122.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 1, FROM 0. TO 250. (KNOTS)

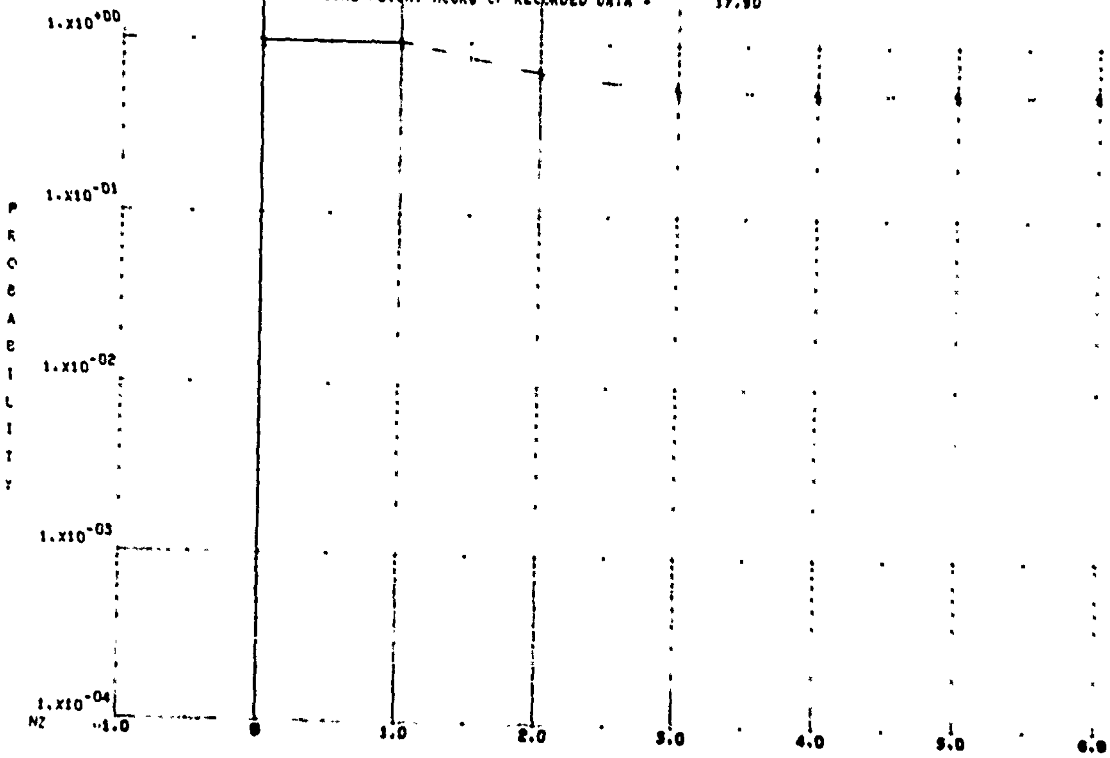
ALTITUDE, HP, INTERVAL NO. 4, FROM 15000. TO 25000. (FEET)

CASE NO. 12

Figure 44

AECD-EF
100 000

PROBABILITY OF VARIABLE'S PEAK EXCEEDING A VALUE OF THE VARIABLE (NZ)
GIVEN THE INTERVALS OF W , VE, AND , HP
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.90



NORMAL LOAD FACTOR, NZ

SYMBOL	WEIGHT, W, (POUNDS) INT.NO.	FROM	TO	NO. OF PEAKS, (NZ) TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	228.	0.	228.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 2, FROM 250. TO 300. (KNOTS)

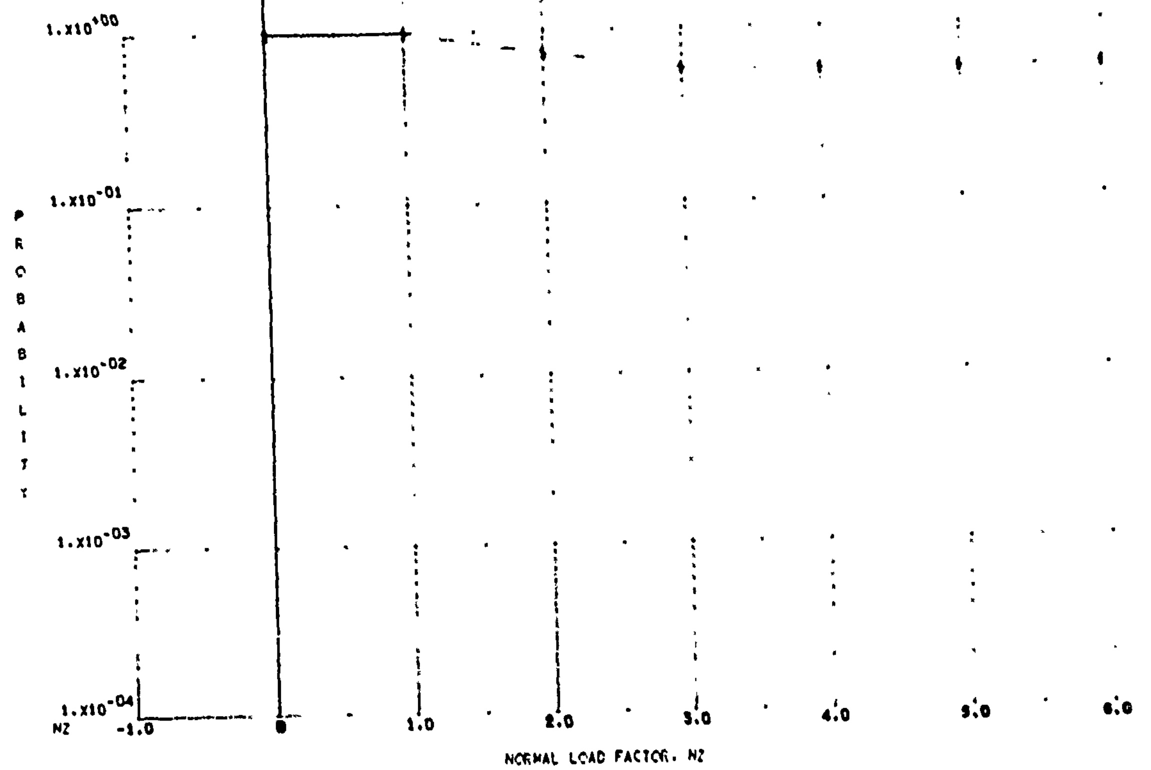
ALTITUDE, HP, INTERVAL NO. 4, FROM 15000. TO 25000. (FEET)

CASE NO. 12

Figure 45

ASCC-EF
110 000

PROBABILITY OF VARIABLE'S PEAK EXCEEDING A VALUE OF THE VARIABLE (NZ)
GIVEN THE INTERVALS OF W , VE, AND HP
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.90



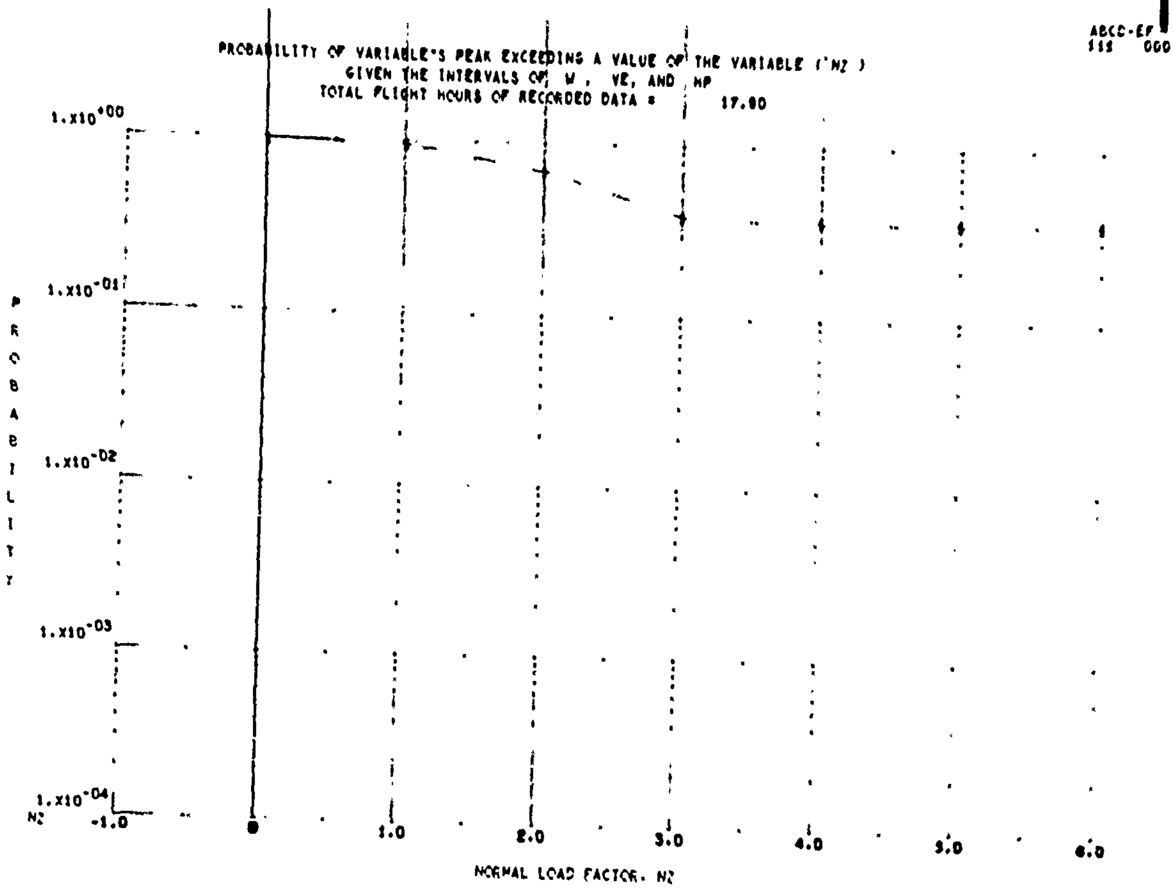
	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	347.	5.	342.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 3, FROM 300. TO 350. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 4, FROM 15000. TO 25000. (FEET)

CASE NO. 12

Figure 46



	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	103.	0.	103.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 4, FROM 350. TO 400. (KNOTS)

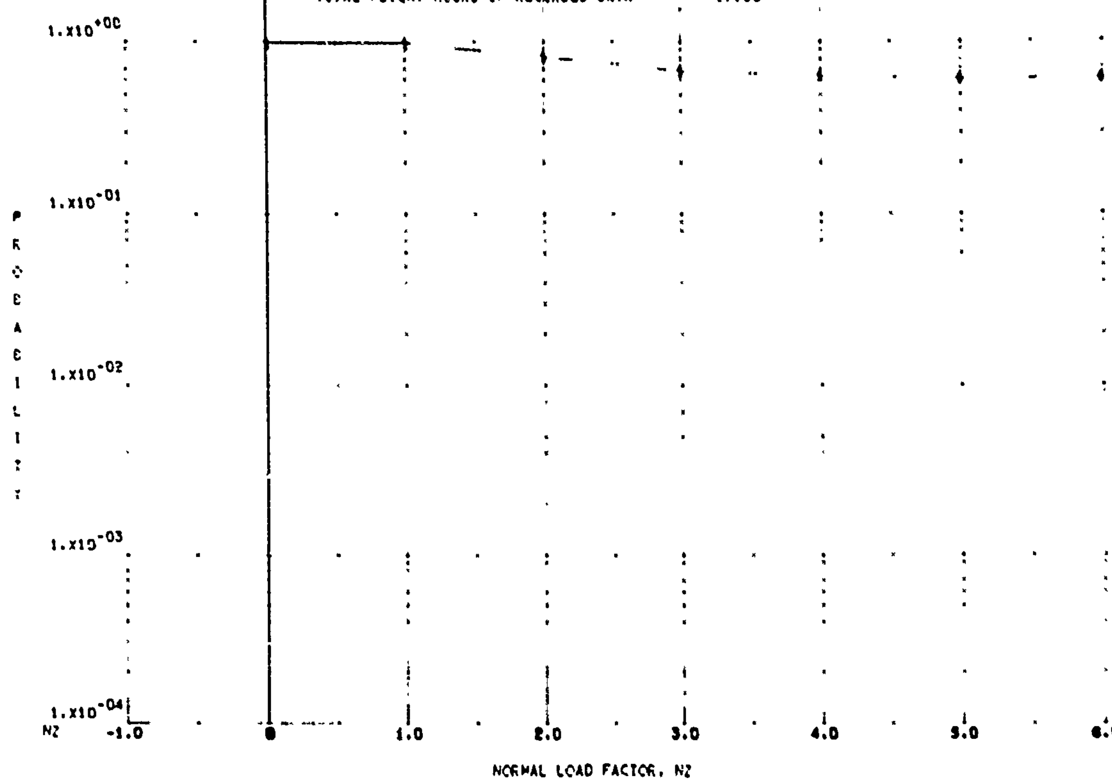
ALTITUDE, HP, INTERVAL NO. 4, FROM 15000. TO 25000. (FEET)

CASE NO. 12

Figure 47

ABCD-EF
118 000

PROBABILITY OF VARIABLE'S PEAK EXCEEDING A VALUE OF THE VARIABLE (NZ)
GIVEN THE INTERVALS OF W , VE, AND , HP
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.90



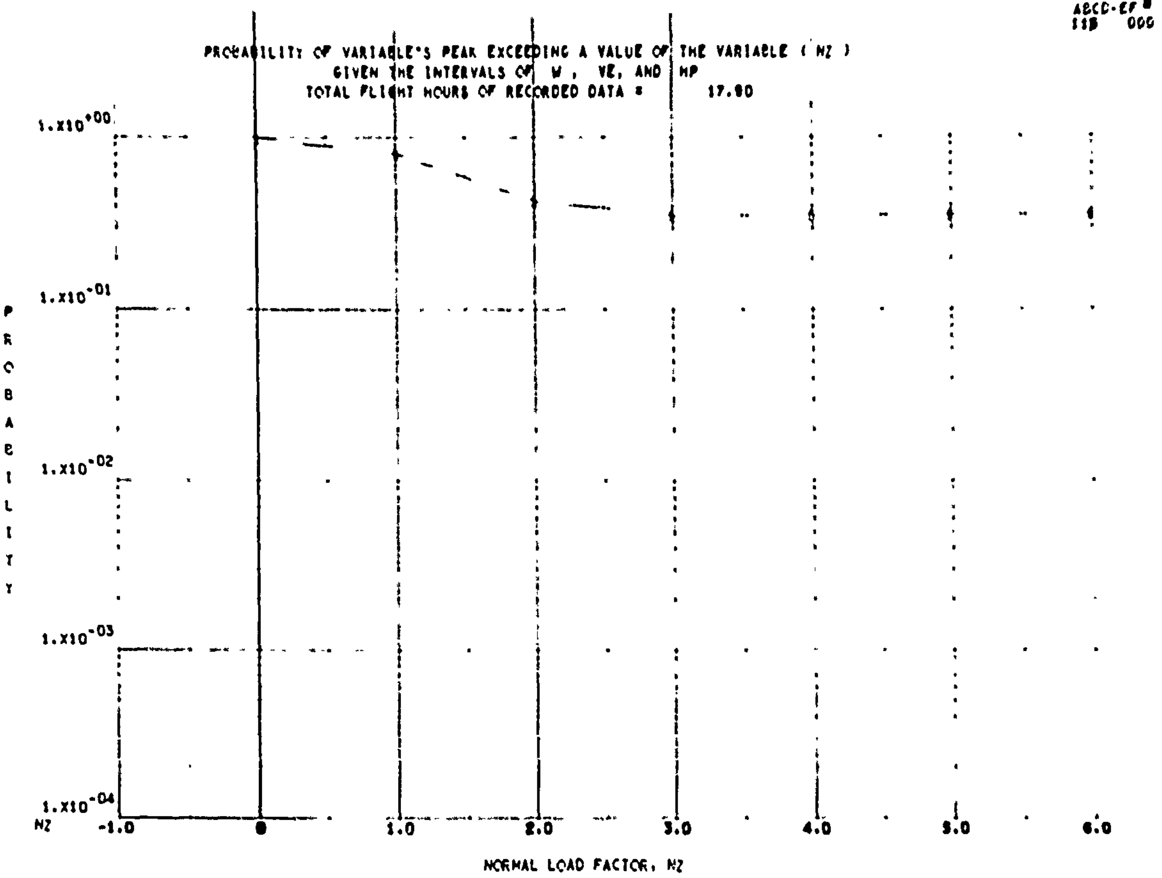
	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	44.	0.	44.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 5. FROM 400. TO 450. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 4. FROM 15000. TO 25000. (FEET)

CASE NO. 18

Figure 48



SYMBOL	WEIGHT, W, (POUNDS) INT.NO.	FROM	TO	NO. OF PEAKS, (NZ) TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	93.	0.	93.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 6, FROM 450. TO 500. (KNOTS)

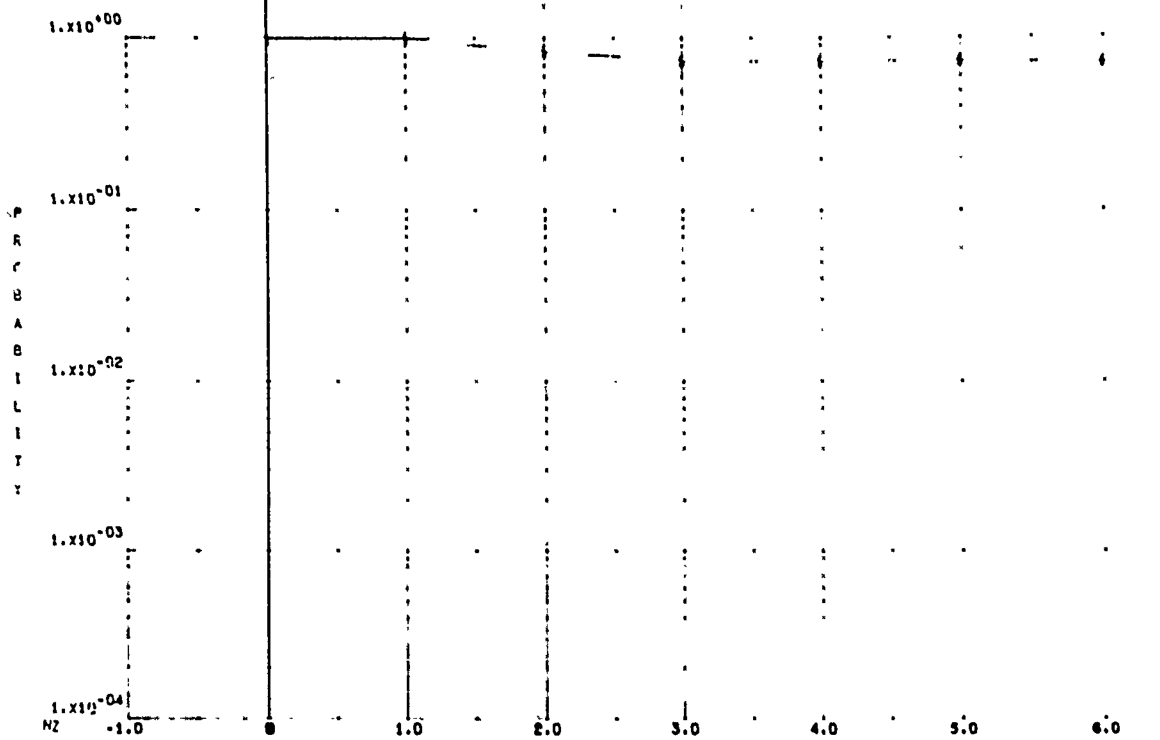
ALTITUDE, HP, INTERVAL NO. 4, FROM 15000. TO 25000. (FEET)

CASE NO. 12

Figure 49

ASCC-EF
114 000

PROBABILITY OF VARIABLE'S PEAK EXCEEDING A VALUE OF THE VARIABLE (NZ)
GIVEN THE INTERVALS OF W , VE, AND HP
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.80



NORMAL LOAD FACTOR, NZ

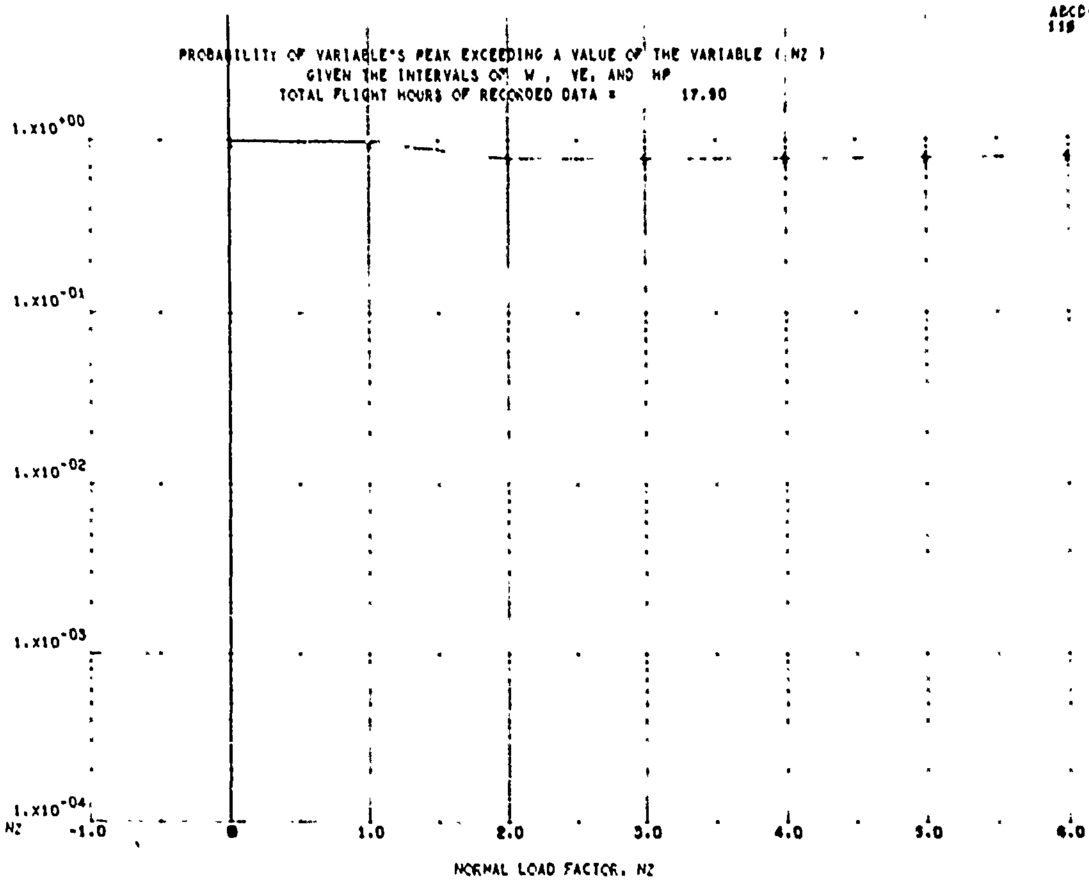
	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	38.	0.	38.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	43000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 7, FROM 500. TO 800. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 4, FROM 15000. TO 25000. (FEET)

CASE NO. 12

Figure 50



		WEIGHT, W, (POUNDS)		NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	117.	0.	117.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 1, FROM 0. TO 250. (KNOTS)

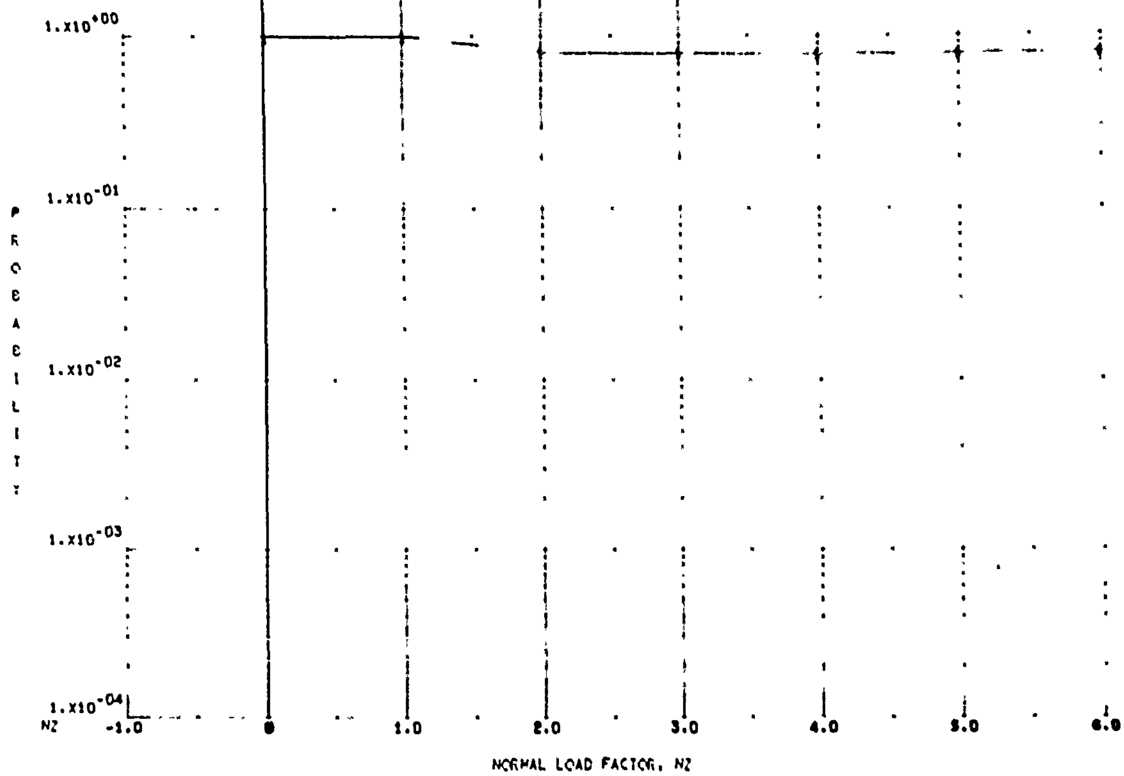
ALTITUDE, HP, INTERVAL NO. 5, FROM 25000. TO 50000. (FEET)

CASE NO. 12

Figure 51

ABCD-EF
118 000

PROBABILITY OF VARIABLE'S PEAK EXCEEDING A VALUE OF THE VARIABLE (NZ)
GIVEN THE INTERVALS OF W , VE, AND HP
TOTAL FLIGHT HOURS OF RECORDED DATA = 17.80



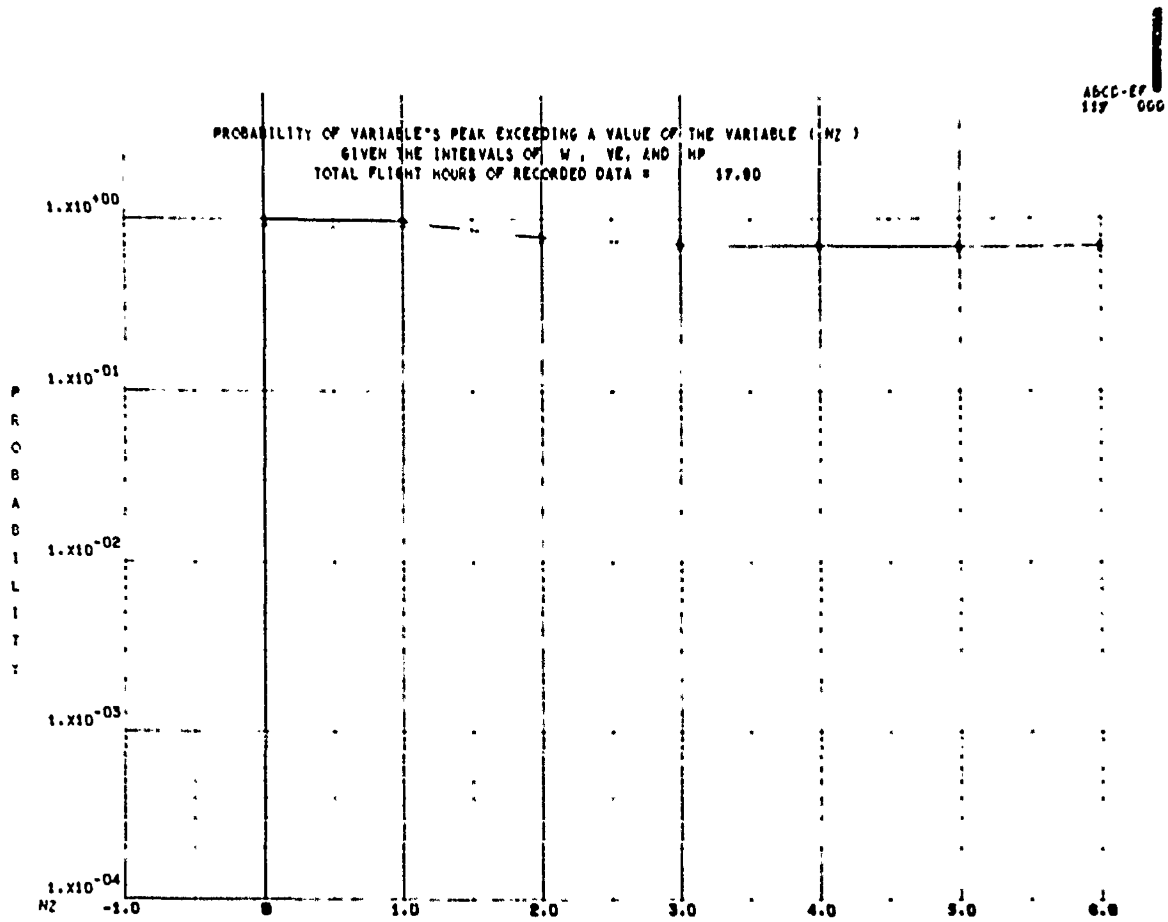
	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	415.	0.	415.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 2, FROM 250. TO 300. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 5. FROM 25000. TO 30000. (FEET)

CASE NO. 12

Figure 52



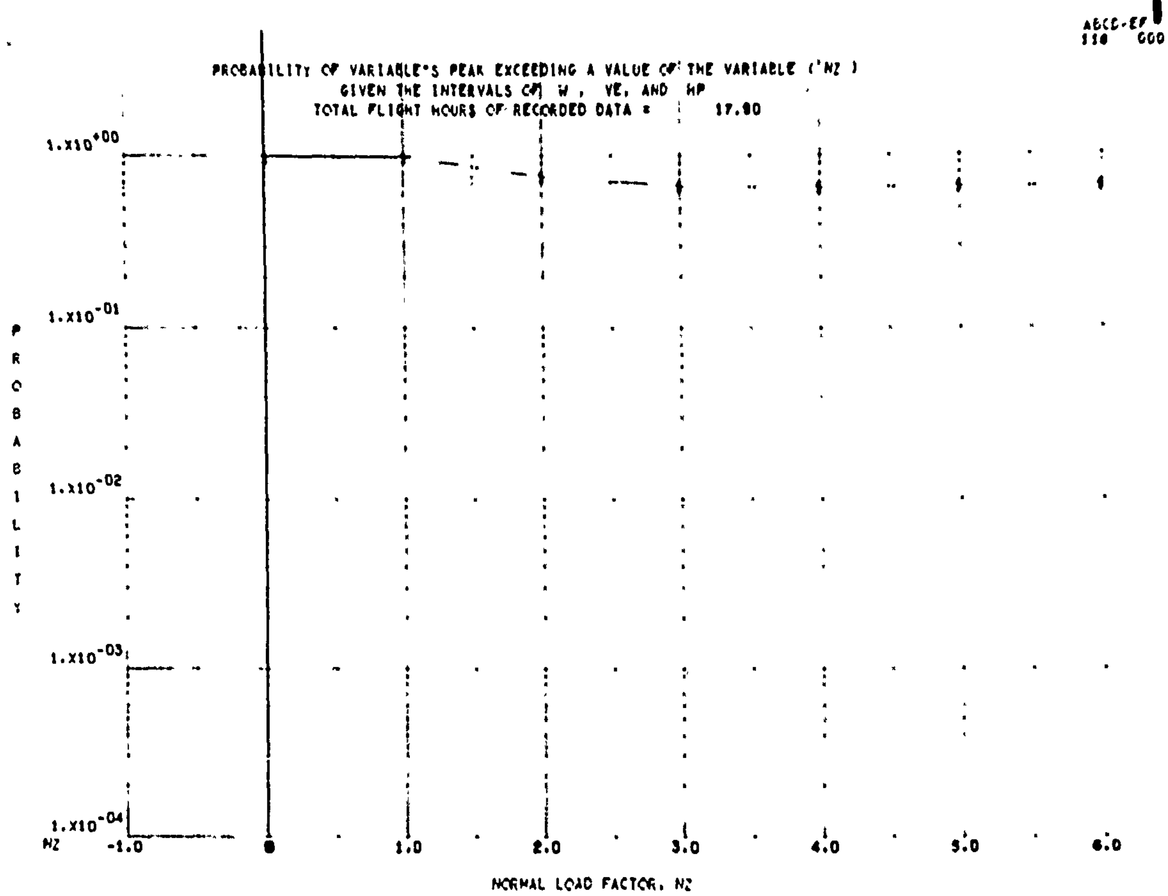
	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	267.	0.	267.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 3, FROM 300. TO 350. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 5, FROM 25000. TO 50000. (FEET)

CASE NO. 12

Figure 53



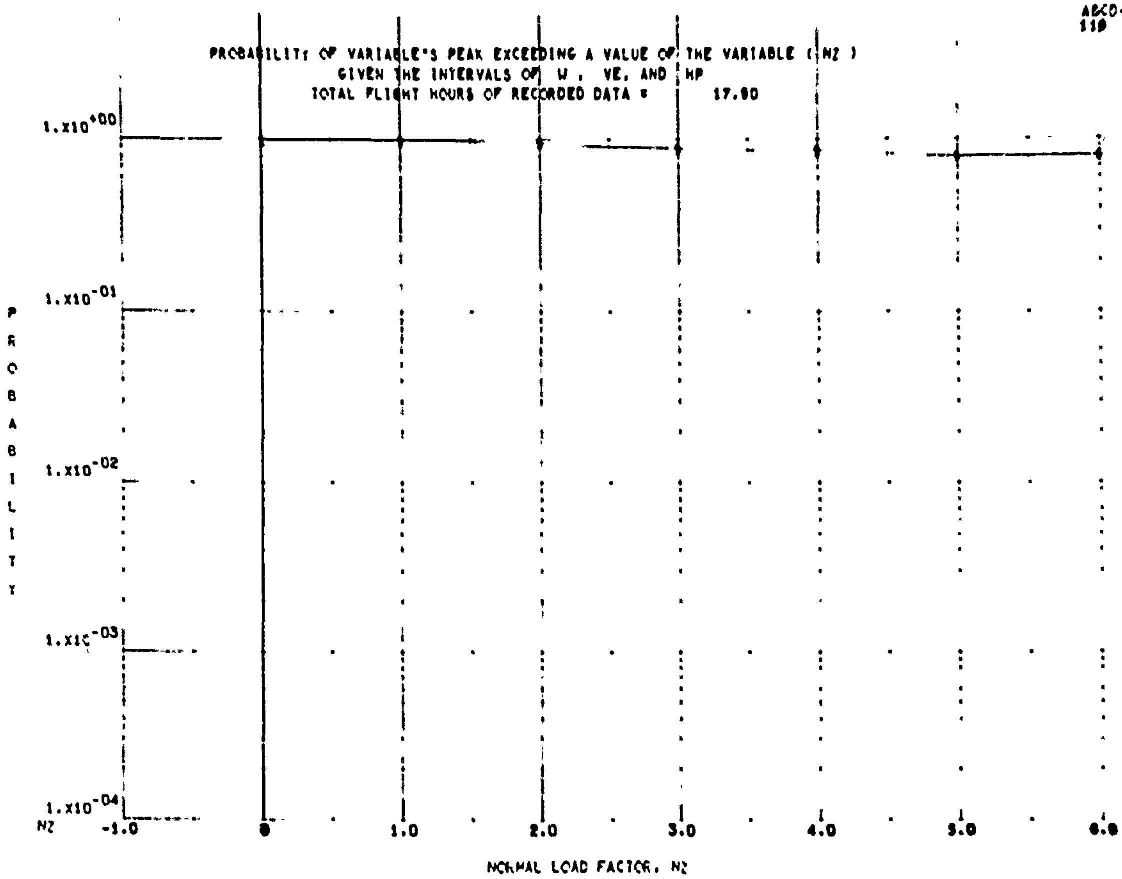
	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	89.	0.	89.
2	2	35000.	40000.	0.	0.	0.
3	3	40300.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 4, FROM 350. TO 400. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 5. FROM 25000. TO 30000. (FEET)

CASE NO. 19

Figure 54



	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	75.	0.	75.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

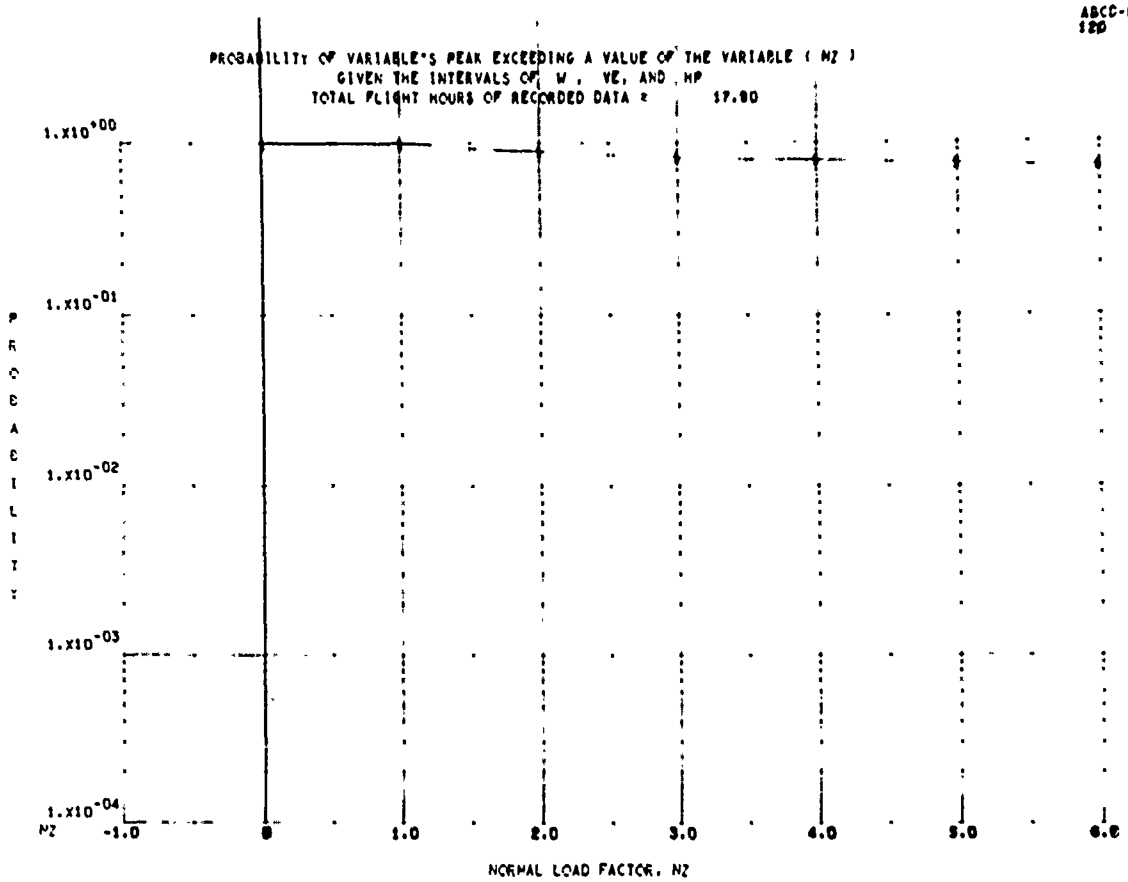
VELOCITY, VE, INTERVAL NO. 5, FROM 400. TO 450. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 5, FROM 25000. TO 50000. (FEET)

CASE NO. 18

Figure 55

ABCD-EF
120 000



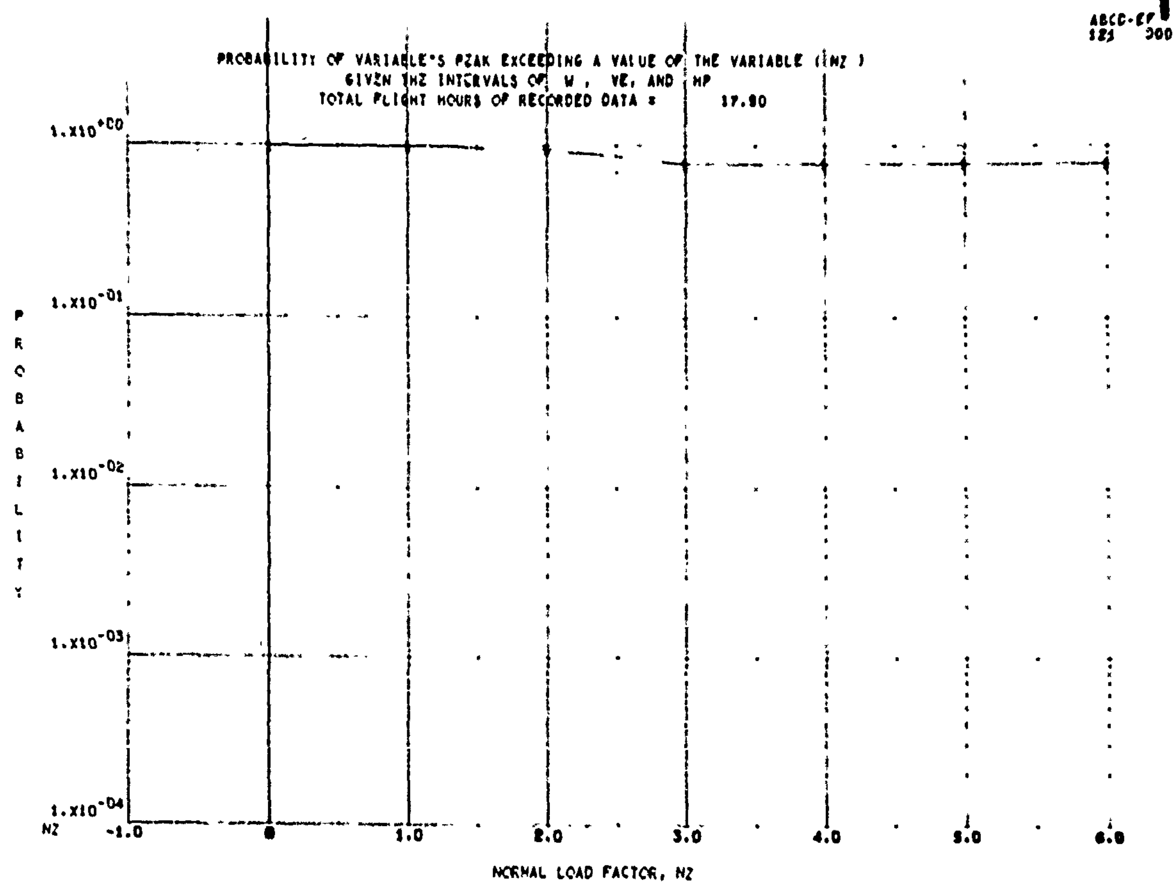
	WEIGHT, W, (POUNDS)			NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	29.	0.	29.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	0.
4	4	45000.	50000.	0.	0.	0.
5	5	50000.	55000.	0.	0.	0.

VELOCITY, VE, INTERVAL NO. 6, FROM 450. TO 500. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 5, FROM 25000. TO 30000. (FEET)

CASE NO. 12

Figure 56



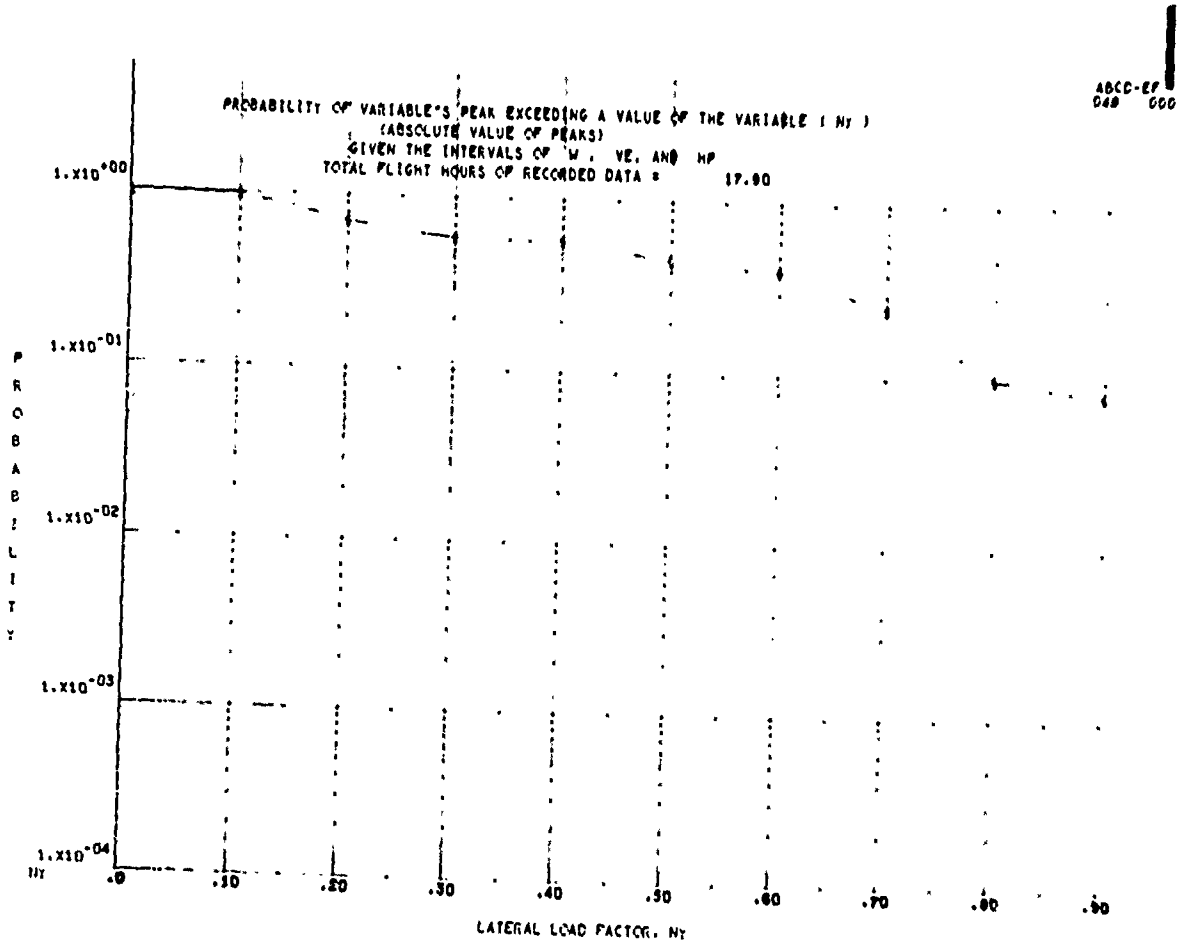
WEIGHT, W, (POUNDS)				NO. OF PEAKS, (NZ)		
SYMBOL	INT.NO.	FROM	TO	TOTAL	NEGATIVE	POSITIVE
1	1	25000.	35000.	19.	0.	19.
2	2	35000.	40000.	0.	0.	0.
3	3	40000.	45000.	0.	0.	U.
4	4	45000.	50000.	0.	0.	U.
5	5	50000.	55000.	0.	0.	U.

VELOCITY, VE, INTERVAL NO. 7, FROM 500. TO 600. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 5, FROM 25000. TO 30000. (FEET)

CASE NO. 12

Figure 57



SYMBOL	INT.NO.	WEIGHT, W, (POUNDS) FROM	TO	NO. OF PEAKS, (NY) TOTAL
1	1	25000.	35000.	4025.
2	2	35000.	40000.	0.
3	3	40000.	45000.	0.
4	4	45000.	50000.	0.
5	5	50000.	55000.	0.

VELOCITY, VE, INTERVAL NO. 1, FROM 0. TO 250. (KNOTS)

ALTITUDE, HP, INTERVAL NO. 1, FROM 0. TO 2000. (FEET)

CASE NO. 10

Figure 58